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Baby food pouch use, baby-led weaning, and dental health in New Zealand infants

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Abstract

Background and objectives: The popularity of the baby food pouch method of food delivery, with the inherent possibility of prolonged contact between potentially cariogenic food and developing teeth, has raised concerns about potential harm to infants' teeth. However, there has been no research to date, nor has the possible impact of baby-led weaning (BLW) on dental health been investigated. This study reports the relationship between baby food pouch use, BLW, and the dental health of New Zealand (NZ) infants 7 to 10 months of age. **Methods:** The dental health of 438 infants aged 6.95 to 10.01 months was assessed using dental photography in the First Foods New Zealand (FFNZ) observational cross-sectional study. Caregivers completed a questionnaire on infant feeding habits. **Results:** Of 438 participants, 44.3% (n=194) had no erupted teeth at the age they participated (mean 8.3 months), and 32% (n=140) had two erupted teeth, with only 2% (n=9) having one erupted tooth. In total, 52.3% (229) of infants were consuming baby food pouches ≥ 1 times/week, but only 35 (15.3%) infants consumed these pouches by feeding from the nozzle. No infant had detectable caries and only two infants had evidence of developmental defects of enamel. **Conclusion:** We were unable to assess associations between method of feeding and tooth health as no infants had dental caries and only two had developmental defects of enamel. We cannot exclude the possibility that associations may be observed at older ages when more infants have erupted teeth.

Introduction

The emergence of teeth is a significant milestone in growth and development. Primary teeth usually start to erupt at around six months of age, and this process can continue to three years of age (Ogodescu *et al.*, 2022). The sequence of tooth emergence in both maxillary and mandibular arches typically starts with the central incisor, followed by the lateral incisor, first molar, canine, and then second molar (Ogodescu *et al.*, 2022). This eruption sequence can be influenced by genetics, hormones, gender, ethnicity, nutrition, socio-economic conditions, and growth parameters (Poureslami *et al.*, 2015). Primary teeth play an important role in the growth of facial muscles and speech, serving as a reference for the proper alignment of permanent teeth as they emerge (Lynch, 2013).

Complementary feeding refers to the transition from a milk-only diet in infancy (birth to ~6 months of age) to consuming family food by around 12 months of age through the introduction of semi-solid then solid foods (Ministry of Health, 2021). Traditional methods of complementary feeding generally commence with spoon-feeding an infant puréed food before gradually moving on to more textured foods. Recently, baby-led weaning (BLW) has become more popular, with around 50% of New Zealand families having tried BLW, and 30% following it regularly (Fu *et al.*, 2018). With BLW, purées are bypassed, and solid foods are presented in finger form to the infant from the start of complementary feeding. Infants feed themselves without any help from their caregiver with potential food choices including vegetable sticks, fruit pieces, meat, bread, or other baked goods. However, health professionals have expressed concern that unhealthy foods can also be

solid foods in finger form, such as chocolate biscuits (Cameron *et al.*, 2012), which might have implications for infant dental health.

Baby food pouches are another alternative to more traditional infant feeding and are a fast-growing sector of the commercial infant food market (Griggs, 2019). They contain fruits, vegetables, savoury meals, sweet meals, and dairy in a puréed form (Haszard *et al.*, 2024), and while they contain relatively low amounts of added sugars, except for dairy foods, they can be high in total sugars because of their fruit content (Katiforis *et al.*, 2021). This ready-made food is convenient and infants and toddlers can feed themselves. However, this also means there is potential for prolonged contact between cariogenic food and developing teeth, which raises concerns about the health of teeth, including the risk of early childhood caries (Crawley and Westland 2017; Theurich, 2018).

An important risk factor for dental caries and tooth wear is developmental defects of enamel (DDE) in the primary dentition (Castañeda-Sarmiento *et al.*, 2022). The disruption of normal structure and function of the enamel weakens the teeth, making the enamel more vulnerable to effects of acidogenic bacteria. To reduce the risk of dental caries associated with enamel defects, it is necessary to practice good oral hygiene and to limit intakes of sugary foods.

Early diagnosis is paramount to successful management (Stookey *et al.*, 1999). The most common method of diagnosis is visual and tactile inspection of the teeth for signs of decay such as cavities, white spots, and areas of demineralisation. Given the limitations of radiographs with the likelihood of movement in infants, photography



is becoming increasingly common for diagnosing and documenting dental caries and enamel defects (Casaglia *et al.*, 2016). Intra-oral photographs are taken of the teeth (Casaglia *et al.*, 2016) which is as effective as the visual system in terms of diagnosis (Boye *et al.*, 2013), while also reducing examiner bias and enabling remote scoring and archiving.

The aim of this study was to determine, using dental photography, whether there was an association between use of baby food pouches, or following a baby-led weaning approach to infant feeding, and dental caries or DDE in 7-10-month-old NZ infants.

Methods

The First Foods New Zealand (FFNZ) study was approved by Health and Disability Ethics Committees New Zealand (approval number 19/STH/151). Caregivers provided written informed consent prior to participation, including consent to take the dental photographs.

As specific study methods are explained in detail in a published protocol paper (Taylor *et al.*, 2021), only methods of direct relevance to this paper are provided here. Infants aged 7.0 to 10 months were recruited from Auckland and Dunedin by advertisement and word-of-mouth (July 2020–February 2022) with community partnership to ensure representative numbers of Māori, Asian, and Pacific participants. Eligible caregivers were at least 16 years of age, lived in the Auckland or Dunedin regions, and were able to communicate in English. Infants were not eligible if they had recently taken part in a nutrition intervention study that involved changes to how they were fed. It was not possible for researchers to collect photographs from participants in Auckland during COVID epidemic Level 2 restrictions because of the proximity required between the researcher and the infant. Neither centre was able to collect photographs during Level 3 or 4 restrictions.

Infants and their main caregiver attended two appointments. At the first appointment, caregivers completed an online REDcap (Harris *et al.*, 2009, 2019) questionnaire on maternal ethnicity, education and work status, and childcare use. Household socioeconomic deprivation was determined using the New Zealand Deprivation Index (NZDep18) (Atkinson *et al.*, 2019). Feeding questions asked when solid food was first introduced and the feeding approach when solids were started, at six months and at the current age. Caregivers were asked to recall frequency of pouch use when solids were first introduced, defined as: “Never” – had never used pouches up to that age; “Infrequently” – used pouches less than weekly; “Sometimes” – used pouches one to four times a week; and “Frequently” – used pouches five or more times a week. Frequency of intake was assessed similarly at the current age but with the category “Never” expanded to “Never or not in the past month”. Baby-led weaning status was defined as we have previously (Taylor *et al.*, 2017): ‘traditional spoon-feeding’ described infants who were ‘spoon-fed by an adult’ or ‘mostly spoon-fed by an adult, some baby feeding themselves’; ‘partial BLW’ was defined as the infant being ‘about half spoon-fed by an adult and half baby feeding themselves’; and ‘full BLW’ was defined as ‘mostly baby feeding themselves, some

spoon feeding by an adult’ or ‘baby feeding themselves’.

Dental health information from questionnaires included the age of first tooth eruption, oral hygiene methods, and any concerns about the infant’s teeth, mouth, or tongue.

During the second appointment, clinical dental photographs were taken of the infant’s oral cavity. Each set of photographs was taken by one of 13 members of the team, following a pretested protocol and training from the primary dental investigator, a qualified dentist (LT). Photographic equipment was standardised and comprised an Oppo Reno2 Z (Oppo, Dongguan, Guangdong, China) mobile phone attached to a Smile Lite MDP (Smile Line SA, St-Imier, Switzerland) light source designed specifically for dental photography (Harden, 2020). Photographs were cropped and resized without distorting the image to allow for comparability between photographs. The photographs were then imported into a PowerPoint (Microsoft Corporation, Redmond, Washington, USA) template and assessed by LT using validated indices for dental caries, developmental defects of enamel, gingival status, eruption phase and intervention urgency, (Hulland *et al.*, 2000; World Health Organization, 2013). A random sample was reassessed by another dental researcher (AM). These assessments were compared, and discrepancies were discussed to ensure standardised interpretation against these validated codes. Inter-rater reliability was calculated from 480 individual assessments (five assessments for each of eight teeth) of 12 randomly selected templates with complete agreement for 473 assessments. A Cohen’s Kappa value of 0.66 was calculated, which can be interpreted as substantial agreement.

Statistical analyses were carried out using Stata SE version 17.0 (StataCorp). Descriptive statistics were used to summarise the questionnaire and dental data. A probability value of $p < 0.05$ was considered to indicate statistical significance. Poisson regression was used to calculate incident rate ratios which are reported with 95% confidence intervals.

Results

Participants

Of the 625 infants in FFNZ, one caregiver did not complete the dental questions, and 438 (70.1%) underwent the oral health (photographic) assessment so were included in this analysis. Participant demographic details are presented in Table 1. Infants who completed the photographic assessment were 6.95 to 10.09 months of age, with a mean of 8.3 months.

Tooth eruption

Table 2 shows the number of teeth erupted in the whole sample and by infant ethnicity. No statistical tests were performed given the small numbers in some categories. Six months was the most common reported age for first tooth eruption (19.2%) followed by seven months (18.0%). In total, 31.1% of caregivers reported that their infant had no visibly erupted teeth. However, analysis of the dental photographs of the 438 participants who had photographic data showed that in fact 44.3% ($n=194$) of infants had no teeth erupted. The next highest prevalence was for two

Table 1. Demographic characteristics of participants

	Full questionnaire sample		Sample with oral assessment	
N	624 ¹		438	
Infant characteristics				
Age, mean (SD) months	8.4	(0.8)	8.3	(0.8)
Sex, n (%) female	289	(46.3)	205	(46.8)
Ethnicity, n (%)				
Māori	131	(21.0)	102	(23.3)
Pacific	43	(6.9)	29	(6.6)
Asian	90	(14.4)	51	(11.6)
NZ European	344	(55.1)	256	(58.5)
Others	16	(2.6)	12	(2.7)
Preterm birth (<37 weeks), n (%)	46	(7.4)	25	(5.7)
In childcare, n (%)	109	(17.5)	83	(19.0)
Caregiver characteristics				
Age, mean (SD) years	32.7	(4.9)	32.7	(4.8)
Relationship to infant, n (%) mother	616	(98.7)	433	(98.9)
Ethnicity, n (%)				
Māori	85	(13.6)	62	(14.2)
Pacific	32	(5.1)	19	(4.3)
Asian	84	(13.5)	45	(10.3)
NZ European	408	(65.4)	303	(69.2)
Others	15	(2.4)	9	(2.1)
Highest level of education, n (%)				
School	94	(15.1)	66	(15.1)
Polytechnic	125	(20.1)	80	(18.3)
University	404	(64.9)	292	(66.7)
Employment status, n (%)				
Full-time	70	(11.2)	49	(11.2)
Part-time	137	(22.0)	101	(23.1)
Other	417	(66.8)	288	(65.8)
Household characteristics				
Socioeconomic deprivation, n (%) ²				
1-3 (Low)	180	(28.9)	125	(28.5)
4-7	281	(45.0)	200	(45.7)
8-10 (High)	163	(26.1)	113	(25.8)
Number of children in household, n (%)				
1	283	(45.4)	185	(42.3)
2	199	(31.9)	155	(35.5)
3	95	(15.3)	69	(15.8)
4 or more	46	(7.4)	28	(6.4)
Number of adults in household, n (%)				
1	25	(4.0)	16	(3.7)
2	516	(82.7)	366	(83.6)
3	42	(6.7)	25	(5.7)
4 or more	41	(6.6)	31	(7.1)

¹ Of the 625 participants, one did not complete any of the dental questions, so was excluded from this analysis.² Household socioeconomic deprivation defined using the NZDep18 index. The index uses census data that reflects the extent of material and social deprivation to construct deciles from 1 (least deprived) to 10 (most deprived)] (Atkinson et al., 2019).



erupted teeth (32.0%, n=140). Two percent of infants (9) had only one erupted tooth, and the remainder had between three and eight erupted teeth.

Infant feeding approach and dental health

Most infants were introduced to solids around five (39.5%) or six (36.5%) months of age. Only eight infants (1.8%) were introduced to solids before four months and nine (2.1%) infants after six months. Traditional spoon feeding (TSF) was the most common feeding practice when solids were introduced (84.6%), but by the average age of 8.4 months

in this study, more than half of caregivers indicated they were using at least a partial BLW approach (Table 3).

When solid foods were first introduced, 84.5% of participants reported they never used food pouches, with 8.5% using them frequently. By six months of age, 18.1% of participants were using them sometimes and 18.6% frequently, the infants' current age (mean 8.3 months), where 27.7% of participants reported using them frequently i.e. five or more times a week (Table 4). These proportions increased further at the infants' current age (mean 8.3 months), where 27.7% of participants reported using them

Table 2. Number of teeth erupted by infant ethnicity in infants aged 7.0 to 10.01 months

Ethnicity ¹	n (%)	Number of teeth ² n (%)									
		0	1	2	3	4	5	6	7	8	
European	256 (58.4)	115 (44.9)	4 (1.6)	85 (33.2)	4 (1.6)	25 (9.8)	7 (2.7)	11 (4.3)	3 (1.2)	2 (0.8)	
Māori	102 (23.3)	38 (37.3)	4 (3.9)	34 (33.3)	7 (6.7)	11 (10.8)	1 (1.0)	1 (1.0)	1 (1.0)	5 (4.9)	
Asian	51 (11.6)	24 (47.1)	1 (2.0)	15 (29.4)	0 (0.0)	6 (11.8)	3 (5.9)	1 (2.0)	1 (2.0)	0 (0.0)	
Pacific	29 (6.6)	17 (58.6)	0 (0.0)	6 (20.7)	0 (0.0)	3 (10.3)	1 (3.4)	1 (3.4)	1 (3.4)	0 (0.0)	
Total	438	194 (44.3)	9 (2.0)	140 (32.0)	11 (2.5)	45 (10.3)	12 (2.7)	14 (3.2)	6 (1.4)	7 (1.6)	

¹ Information on the age of each infant was not available for this analysis so comparisons between ethnicities, which may have different age distributions, should not be made

² Partial eruption or complete emergence stage of eruption

Table 3. Feeding approach at different ages

n = 438 (%)	
Feeding approach when started solids	
Traditional spoon feeding	371 (84.6)
Partial baby-led weaning	16 (3.7)
Full baby-led weaning	51 (11.7)
Feeding approach at 6 months of age	
Traditional spoon feeding	334 (76.3)
Partial baby-led weaning	47 (10.7)
Full baby-led weaning	57 (13.0)
Feeding approach at current[†] age	
Traditional spoon feeding	210 (47.9)
Partial baby-led weaning	109 (24.9)
Full baby-led weaning	119 (27.2)

[†] Current feeding approach determined when infants were between 6.95 and 10.01 months of age (mean age: 8.3 months)

Table 4. Frequency and method of baby food pouch use[†]

n = 438 (%)	
Frequency of pouch consumption when started solids	
Never	370 (84.5)
Infrequently (<4/month)	6 (1.3)
Sometimes (1–4/week)	25 (5.8)
Frequently (5+/week)	37 (8.5)
Frequency of pouch consumption at 6 months of age	
Never or not in the past month	231 (52.6)
Infrequently (<4/month)	47 (10.7)
Sometimes (1–4/week)	79 (18.1)
Frequently (5+/week)	81 (18.6)
Frequency of pouch consumption at current[†] age	
Never or not in the past month	109 (24.8)
Infrequently (<4/month)	100 (22.8)
Sometimes (1–4/week)	108 (24.7)
Frequently (5+/week)	121 (27.7)
Method of pouch consumption for “sometimes”[§] and “frequent”[¶] users at current[†] age	
n = 229	
Mostly from spoon	176 (77.0)
Half nozzle, half spoon	18 (7.7)
Mostly from nozzle	35 (15.3)

[†] Data presented as n (%)

[†] Current feeding approach determined when infants were between 6.95 and 10.01 months of age (mean age: 8.3 months)

[§] “Sometimes” indicates that baby food pouches were used 1–4 times a week

[¶] “Frequently” indicates that baby food pouches were used 5 or more times a week

frequently. For participants who were current “sometimes” or “frequent” users of baby food pouches (i.e. consuming pouches one or more times a week in the past month), 77.0% used a spoon for feeding the pouch food, whereas 15.3% ($n=35$, 8.0% of all 625 participants) were consuming the pouch food directly through the pouch nozzle most of the time (Table 4).

Discussion

In this group of 7–10-month-old infants, almost half had no erupted teeth at the time of the study. This meant we were unable to measure associations between the use of baby food pouches or BLW and dental caries as no dental caries were observed. Developmental defects of enamel were present in just two infants, both of whom had a single tooth with a demarcated opacity.

There are currently no published studies that have looked at the effect of baby food pouch feeding on the dental health of infants. This is despite strong concerns about their use by expert groups who have warned about “obscene levels of sugar in popular baby food pouches” (‘As sugary as Cola’: Dentists call for sweeping action on baby pouches, 2022). Investigation shows that much of the commentary has been based on studies that have simply reported on the sugar content of baby food pouches (Brunacci *et al.*, 2023; Katiforis *et al.*, 2021; Padarath *et al.*, 2020;), rather than on the actual contribution such baby food pouches make to the diet of infants. This is a crucial gap because the amount of the baby pouch food eaten, the frequency of consumption, and the extent to which the pouch food is consumed using the nozzle must be considered when looking at potential outcomes including dental health. Our research has previously shown that baby food pouches contribute half (49%) of the total sugars from complementary foods in infants who use baby food pouches (Haszard *et al.*, 2024). However, baby food pouches were relatively small contributors to the overall diet – contributing just 11% of the energy intake from complementary foods (26% in consumers of baby food pouches) (Haszard *et al.*, 2024). At this age, complementary foods contribute only part of the total energy intake, with infant milk contributing approximately 78% of energy at 7 months of age (Leong *et al.*, 2018). In total, baby food pouches on average contributed 4g total sugars to the infant diet – almost all of which was from fruits and vegetables (just 0.3g was as added sugars). It is also important to acknowledge that many of the infants either did not yet have teeth (44.3%) or had teeth that had only recently erupted, so the opportunity for exposure of the dentition to the contents of baby food pouches was low or absent for many of our infants. In addition, just 15.3% of infants were both consuming food from a baby food pouch at least once a week and mostly feeding from the nozzle when they did so, limiting the opportunities for tooth erosion from this style of complementary feeding. Our findings are limited to this particular young age group, and future studies will need to investigate whether longer term consumption of baby food pouches has different, deleterious, impacts on dental health, particularly as motor control improves so that it is easier for infants to use the nozzle to feed themselves directly from the baby food pouch.

There also appear to be no published studies that have looked at the effect of baby-led weaning on dental health in infants. Unfortunately, we could not assess any association between use of baby-led weaning and either dental caries or DDE in the current study because the number of affected infants was too small. While concern has been expressed that less healthy foods, including chocolate biscuits, can be solid foods in finger form and, therefore, be self-fed (Cameron *et al.*, 2012), the majority of studies have reported no difference in total sugars intake between BLW and TSF infants (Pearce *et al.*, 2021), or lower intakes in BLW infants (Alpers *et al.*, 2019; Rowan *et al.*, 2021). While one small NZ study (Morison *et al.*, 2016) reported a trend of 42% higher total sugars intake in BLW infants, these analyses referred to total nutrient intake, so may reflect differences in infant milk intake rather than intake of solids themselves.

The eruption time of the first primary tooth of infants in the current study ranged from four to 10 months of age, with just 19.2% of infants having their first tooth erupt by the age of six months. These New Zealand data are similar to Romanian children with a mean age of 7.7 ± 2.28 months (Ogodescu *et al.*, 2022), and Chinese infants with a mean age of 6.82 ± 1.9 months and range of 3–13 months (Wu *et al.*, 2019). Both Ogodescu *et al.*, (2022) and Wu *et al.*, (2019) suggest that there are ethnic- and sex-related differences in the timing of primary tooth eruption. It has been further observed that Caucasians have delayed eruption compared to other ethnicities (Warren *et al.*, 2016). It is difficult to disentangle, however, the extent to which these associations are confounded by other factors. For example, breastfeeding has been associated with later eruption of the first primary tooth (Żądzińska *et al.*, 2015). A later eruption of teeth would therefore be expected in the current study both because most participants in the current study were NZ European (58.5%) and because there was a relatively high rate of breastfeeding in FFNZ study overall (66% at the mean age of 8.4 months (Brown *et al.*, 2023)).

Previous studies have assessed the role of dental photography in the diagnosis of dental caries. For example, a photographic approach to dental screening yielded an acceptable diagnostic level for dental caries in young children when compared to unaided visual dental examination in a small Australian study (Estai *et al.*, 2022). Digital images have been reported to have great potential in dentistry and provide a valuable tool for both oral health screening and research methodology (Thomas *et al.*, 2021). In the current study, the use of photographic assessment allowed for ease of calibration among the assessors and for data to be collected from a large and varied group of infants by several researchers. The photographs were easy to obtain using a mobile phone with an attached dental light source, possibly because infants are used to interacting with smartphones in their daily lives. However, it did require the caregiver to assist with positioning the infant and ensuring they remained still so that quality images could be collected.

Strengths and limitations

The strengths of the study include the use of standardised methods to collect dental data from more than 400 infants, and the careful collection of data on baby food pouch use and baby-led weaning. In addition, the demographic profile of the participants reflects the diversity of NZ in terms of ethnicity and socioeconomic deprivation. However, the level of caregiver education was high, which is perhaps reflected in the good oral health of the infants who had teeth. As 44.3% of the infants involved did not have any visible teeth, it would be worthwhile in future studies to include a wider age range in the study, involving older infants. The current study could be extended to reassess this cohort at an older age to determine relative dental outcomes from the onset of complementary feeding to full primary dental status.

Conclusion

We were unable to assess any association between use of baby food pouches or baby-led weaning and either caries or DDE in this sample of 7-9.9-month-old infants due to the very low numbers of infants with poor teeth health. Given these findings, it could be argued that concern about the impact of complementary feeding method on infant teeth is somewhat premature at this age, given that almost half of the current sample did not yet have teeth. Further studies in older infants are required. However, the study did highlight the usefulness of dental photography at this age. Our validation and implementation of a protocol for taking clinical photographs of infants to evaluate infant oral health with a multidisciplinary team has positive practical implications for everyday clinical dental practice, particularly with the increasing interest in remote medicine and dentistry.

Author contributions

Conception and design of the study – all authors
Data collection – LT
Data analysis and interpretation – LT
Drafting and critical revision of the article – all authors
Final approval of the version to be published – all authors

Conflicts of interest

The authors declare no conflicts of interest.

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