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Is higher formula intake and limited dietary diversity in Australian children at 14 months of age associated with dietary quality at 24 months?

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ABSTRACT

A varied and diverse diet in childhood supports optimum long-term preferences and growth. Previous analysis from 14-month-old Australian children in the NOURISH and South Australian Infants Dietary Intake (SAIDI) studies found higher formula intake was associated with lower dietary diversity. This analysis investigated whether formula intake and dietary diversity at 14 months of age is associated with dietary quality at 24 months.

This is a secondary analysis of intake data from NOURISH and SAIDI cohorts. Scores for dietary diversity, fruit variety, vegetable variety and meat/alternative variety were combined using structural equation modelling to form the latent variable 'Dietary quality' (DQ) at age 24 months. A longitudinal model examined influence of formula (grams), cow's milk (grams) and dietary diversity at 14 months and covariates, on DQ.

At age 24 months ($n = 337$) 27% of children obtained a maximum dietary diversity score (5/5). Variety scores were relatively low – with mean variety scores (and possible range) being four for fruit (0–30); five for vegetables (0–36); and three for meat/alternatives (0–8). Dietary diversity at 14 months ($\beta = 0.19$, $p = 0.001$), maternal age ($\beta = 0.24$, $p < 0.001$) and education ($\beta = 0.22$, $p < 0.001$) predicted DQ at 24 months while Child Food Neophobia Score was negatively associated with DQ ($\beta = -0.30$, $p < 0.001$). Formula intake was negatively associated with diversity at 14 months, but not DQ at 24.

Diversity and variety were limited despite sociodemographic advantage of the sample. Diversity at 14 months, degree of neophobia and sociodemographic factors predicted DQ at 24 months. There is an ongoing need to emphasise the importance of repeated early exposure to healthy foods, such that children have the opportunity to learn to like a range of tastes and texture, thereby maximising dietary diversity and quality in infancy and early toddlerhood.

1. Introduction

Food preferences, healthy or otherwise, are hypothesized to develop in early childhood and influence food consumption in later life (Birch & Doub, 2014; Mennella, 2014; Skinner, Carruth, Bounds, & Ziegler, 2002). The Australian Dietary Guidelines recommend that "*by 12 months of age, infants should be consuming a wide variety of foods consumed by the rest of the family*" (National Health and Medical Research Council, 2013). Guidelines emphasise eating foods from each of the five core food groups (fruit, vegetables, meat and alternatives, breads and cereals, milk and dairy products) such that children are exposed to a range of tastes and textures to promote development of healthy food preferences and parents are specifically advised to offer meat or iron-rich alternatives (National Health and Medical Research Council, 2012). However, studies in Australia and overseas consistently report that the dietary intake of

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infants and young children does not align with national nutrition guidelines (Chai et al., 2016; Dwyer, Butte, Deming, Siega-Riz, & Reidy, 2010; Lioret, McNaughton, Spence, Crawford, & Campbell, 2013). Poor diet increases risk of overweight and subsequent development of chronic disease (Magarey, Daniels, Boulton, & Cockington, 2003; Reilly et al., 2003), and in Australia, 23% of children aged 2–4 years are overweight or obese (Australian Bureau of Statistics, 2013b). Identifying modifiable factors that influence food preferences and intake amongst toddlers may inform interventions to improve dietary quality in this age group and subsequent obesity risk.

There are links between early milk feeding practices and later eating patterns (Nicklaus & Remy, 2013). Breastfeeding is hypothesized to support increased dietary variety due to exposure to flavours from breast milk improving subsequent acceptance of solid foods (Hausner, Nicklaus, Issanchou, Mølgaard, & Møller, 2010; Mennella, 2014), however findings are mixed (Scott, Chih, & Oddy, 2012) (Galloway, Lee, & Birch, 2003; Shim, Kim, & Mathai, 2011; Skinner, Carruth, Bounds, Ziegler, & Reidy, 2002). It is plausible and has been suggested that excess consumption of cow's milk or formula *beyond the age of 12 months* may displace intake of solid foods (Cattaneo, Fallon, Kewitz, Mikiel-Kostyra, & Robertson, 2006), with the potential to limit the variety and diversity of foods a child is exposed to at a key period in the development of longer-term food preferences.

Current infant feeding guidelines recommend that toddlers be offered cow's milk (<500 ml/day) or water as a drink, with continued breastfeeding as desired, while special complementary toddler milks or formula are unnecessary (National Health and Medical Research Council, 2012). However, in affluent countries an estimated 16–32% of toddlers are consuming formula (Byrne, Magarey, & Daniels, 2014; Fox, Pac, Devaney, & Jankowski, 2004; Lioret et al., 2013). Our previous cross-sectional analysis of data from 14 month old Australian children participating in the NOURISH and SAIDI studies found higher formula intake was associated with decreased dietary diversity (defined as the number of core food groups eaten on the previous day), independent of socioeconomic factors (Byrne et al., 2014).

Therefore the aim of this longitudinal analysis was to determine if higher formula intake and lower dietary diversity in the NOURISH_SAIDI cohort at 14 months of age independently predicts dietary quality – represented by dietary diversity *and* variety of fruit, vegetables and meat/alternatives - at age 24 months.

2. Materials and methods

2.1. Study design and population

This is a secondary analysis of data from mother-child dyads allocated to the control group of NOURISH - a dual-site randomized controlled trial (RCT) (Daniels et al., 2009), and the observational South Australian Infant Dietary Intake (SAIDI) Study. Details have been published previously (Byrne et al., 2014; Daniels et al., 2009; Daniels et al., 2012). Briefly, the NOURISH RCT evaluated a program for the primary prevention of childhood obesity and SAIDI was a concurrent longitudinal study of Australian children's dietary intakes that used the same recruitment, data collection and dietary intake assessment protocols.

Mother-child dyads were recruited from maternity hospitals in Brisbane, Adelaide and rural South Australia. Inclusion criteria were mothers delivering a healthy infant (≥2500 g, >35 weeks), ≥18 years old, willing and able to attend subsequent assessment sessions and facility with spoken and written English. Only first-time mothers were included within NOURISH. Participants were excluded if the infant was diagnosed with a condition likely to affect normal development or if the mother had a history of domestic violence, intravenous substance abuse, or eating disorders. Consenting mothers were recontacted when their child was between 4 and 7 months of age for full enrolment and baseline assessment. Demographic data were collected at initial recruitment and baseline using self-administered questionnaires. When children were aged between 11 and 17 months mothers completed a single 24 h recall of the child's dietary intake, via telephone interview with a dietitian. At age 21–27 months mothers completed another 24 h recall of the child's dietary intake closely followed by completed a two-day food record. To aid accuracy of data collection during recall and record periods, visual aids with illustrated metric cups and measuring spoons were provided to mothers. Each mother was given a study-specific booklet, so that if the child was in the care of another person, e.g. institutional child-care or grandparent, the carer could record the child's intake and the mother could accurately report it, if a recall was collected the following day. Child length/height and weight (to the nearest 0.01 m and 0.01 kg respectively) were measured by trained research staff or by general practitioner/child health nurse if located in a rural area at age 21–27 months. BMI Z-score was calculated using WHO Anthro 2008 (World Health Organisation, 2009).

Ethical approval was obtained from eleven Human Research Ethics Committees including the Queensland University of Technology, Flinders University and participating hospitals (QUT HREC 00171 Protocol 0700000752).

2.2. Measures

This study utilises dietary intake data from the 24 h recall at age 11–17 months and 24 h recall and 2-day record at age 21–27 months. Items from recalls and records were entered into FoodWorks Professional version 9 which utilised the AUSNUT 2007 database from the 2007 Children's Survey (CSIRO & University of South Australia, 2008). An additional database containing information regarding commercial infant products was created by study staff with nutrient information sourced from websites, manufacturers or nutrient information panels. This dietary analysis software converts all liquid measures to grams. Data were exported into SPSS v21 for analysis.

2.3. Dietary quality

Dietary diversity and variety scores represent two important components of dietary quality - scores for both were calculated using three days of dietary intake data at the 21–27 month assessment. Dietary diversity was defined as the average number of the five core food groups (fruit, vegetables, meat & alternatives, breads & cereals, milk & dairy products - as per the Australian Dietary Guidelines (National Health and Medical Research Council, 2013)) that a child ate from on each of three days, giving a potential score from 0 to 5. Dietary variety was defined as the total number of different sub-groups (within a major food group) a child ate over three days, consistent with previous analyses of this cohort (Perry et al., 2015). Variety scores were defined separately for fruit, vegetables and meat/alternatives groups, each consisting of 30, 36 and 8 subgroups respectively (Appendix 1). A point was given when a food from the sub-group was consumed ≥ once over the three days of intake, regardless of the frequency or quantity eaten and then the points summed to give a variety score for each of the three food groups. Dairy and cereals were excluded from variety analysis as inadequate intake of these food groups, either total amount or variety, is not considered a concern amongst the healthy paediatric population. A finding consistent across dietary intake studies is that