Title page

Title The accuracy of dietary recall of infant feeding and food allergen data

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Keywords: dietary recall, food allergy, infant feeding, recall bias

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ZvZ collected, analysed data and assisted with drafting the manuscript. KM drafted the manuscript. CV designed the study. All authors critically reviewed and approved the final paper.The authors declare that they have no conflict of interests

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Abstract

Background: Research investigating the association of infant dietary factors with later health outcomes often relies on maternal recall. It is unclear what the effect of recall bias is on the accuracy of the information obtained. The aim of this study was to determine the extent of recall bias on the accuracy of infant feeding and food allergen data collected 10 years later.

Methodology: Mothers were recruited from a prospective birth cohort from the Isle of Wight. Mothers were asked when their child was 10 years of age (2011/2012) to complete a retrospective infant feeding questionnaire asking the same questions that were asked in 2001/2002.

Results: 125 mothers participated. There was substantial agreement for recollection of any breast feeding (k = 0.79) and duration of breastfeeding from 10 years earlier (r = 0.84). 94% of mothers recalled accurately that their child had received formula milk. The exact age at which formula milk was first given was reliably answered (r = 0.63). The brand of formula milk was poorly recalled. Recall of age of introduction of solid food was not reliable (r = 0.16). The age of introduction peanuts was the only food allergen that was recalled accurately (86%).

Conclusion: This study highlights the importance of maternal recall bias of infant feeding practices over 10 years. Recall related to breast feeding and formula feeding were reliable, but not age of introduction of solid or allergenic foods, apart from peanut. Caution should be applied when interpreting studies relying on dietary recall.

Keywords: dietary recall, food allergy, infant feeding, recall bias

Introduction

Epidemiological research suggests early dietary exposure is a contributing factor in the development of non-communicable diseases such as obesity, diabetes and food allergy [1–4]. In health conditions with some latency period between dietary exposure and outcome, past dietary exposure is of more relevance than current dietary intake. However collection of data about prior dietary intake is often reliant on memory, either immediate or in the distant past. The accuracy, reliability and validity of retrospectively collected data compared to prospectively collected data is therefore a very important question for nutritional epidemiological research.

Although retrospective data collection has many potential advantages such as reduced study duration and cost, it is highly subject to recall bias. Recall bias is the tendency of subjects to report past events about exposure or outcome in a different manner between the two study periods [5]. This error in recall can lead to misclassification of study subjects with a resultant distortion of measure of association. Hence, recall bias contributes a major threat to the internal validity of studies using self-reported data [6] and potentially may lead to incorrect hypothesis generation.

Longitudinal research examining the effect of infant feeding habits on later health often rely on maternal recall as a proxy measure of infant dietary intake. Outcomes such as adult intelligence, obesity, serum cholesterol and risk of diabetes have all been investigated in their relationship with breast feeding and breast feeding duration [7]. Factors including the period of recall [8], family size [9], type of information recalled and mother's educational level [10] have been found to influence the accuracy of information recalled. Conversely, maternal age, race and the infant's gender does not appear to influence the accuracy of maternal recall.

Overall studies investigating recall of breastfeeding have had inconsistent findings. Bland *et al.* [9] reported that 72% of mothers did not recall the period of exclusive breastfeeding (EBF) accurately 6-9 months post-delivery; with 57% overestimating the duration and 15% underestimating the duration. Agampodi *et al.* [11] reported similar findings at nine months follow up, concluding that estimations of longer than observed EBF were likely to be due to social desirability bias than recall bias. With regard to longer durations of recall, Promislow *et al.* [7] assessed the validity of maternal recall of the duration of breastfeeding in elderly US women 34-50 years later, reporting a sensitivity for recall of having breast fed of 94%. Duration of any breast feeding therefore has been shown to be more reliable than duration of EBF, which was also reported by Natland *et al.* [8,12,13] who assessed reporting accuracy over an 8 year period.

In terms of introduction of solid food, research suggests dietary recall is also unreliable. Gillespie *et al.* [14] reported that the age of introduction of solid foods tended to be overestimated in interviews 1 – 3.5 years after birth, compared to those within 3 weeks of the event. Recall accuracy appears to diminish with increasing time gap. Vobecky *et al.* [8] reported that age at introduction of solids was recalled very poorly after eight years, with a correlation of only 0.16 for meat and 0.35 for cereals. Barbosa *et al.* [15] also found little agreement in the age at introduction of solid foods over a 6 year period of recall. Tienboon *et al.* [16] examined mothers' recall of infant feeding practices after a period of 14 to 15 years, demonstrating the timing of the introduction of solids and duration of breast feeding was less accurately recalled than the recall of any breastfeeding.

Predictors for inconsistencies of recall with infant feeding practices have been shown. Questions described in the literature are not always valid or reliable, for e.g. asking a mother how long she breastfed exclusively for, without explaining exactly what EBF means as well as using the question 'When did you stop breast feeding' to find out when a mother started weaning. Another predictor for inconsistency of recall is when the criteria for agreement changes over the two time points, for example, recording in weeks when a mother started with the introduction of solid foods and asking her to recall in months.

Information regarding timing of introduction of solids food is of particular importance in food allergy as this has led to important hypothesis generation in the past [17]. Food allergy negatively impacts quality of life [18] and has a substantial impact on the health economy [19,20]. As there is currently conflicting evidence in the area of food allergy prevention [21,22], it is particularly important that the evidence generated is robust. Of note, some studies that have investigated pregnancy, breast feeding and weaning practices and the potential effect on the development of food allergy have relied on parents reporting information up to 15 years retrospectively [23]. Despite suspecting that this period of recall in food allergy prevention studies may have an effect on the reliability of the data, it was still used to inform national policies [24]. There is paucity in the literature regarding the effect of recall bias on infant feeding information obtained retrospectively and how this may affect the development of allergic diseases. This study therefore investigated the impact of recall bias on the accuracy of information obtained regarding breast feeding and weaning practices, specifically in relation to food allergy and the introduction of allergenic foods.

Methodology

Parent study

This study formed part of the Food Allergy and Intolerance Research (FAIR) study, an unselected birth cohort study from the Isle of Wight. Data was obtained in 2001/2002 from 969 families investigating factors associated with maternal dietary intake, feeding and weaning practices in relation to the development of food hypersensitivity in the infant. Methods and data from this study have been published previously in detail [25–27].

In brief, all pregnant mothers with an approximate delivery date between 1st September 2001 and 31st August 2002 were approached at antenatal clinics. At 36 weeks gestation, a validated maternal food frequency questionnaire was completed [25]. At 3, 6, 9 and 12 months, information was obtained regarding feeding practices and reported symptoms of atopy, using a standardised questionnaire. Children were seen at 1, 2 and 3 years when a medical assessment was performed. Participants were invited for further follow up in 2012, when the children were between 9 and 11 years of age. A flow diagram of the study population showing the stages from recruitment to the 10 year follow up is shown in figure 1.

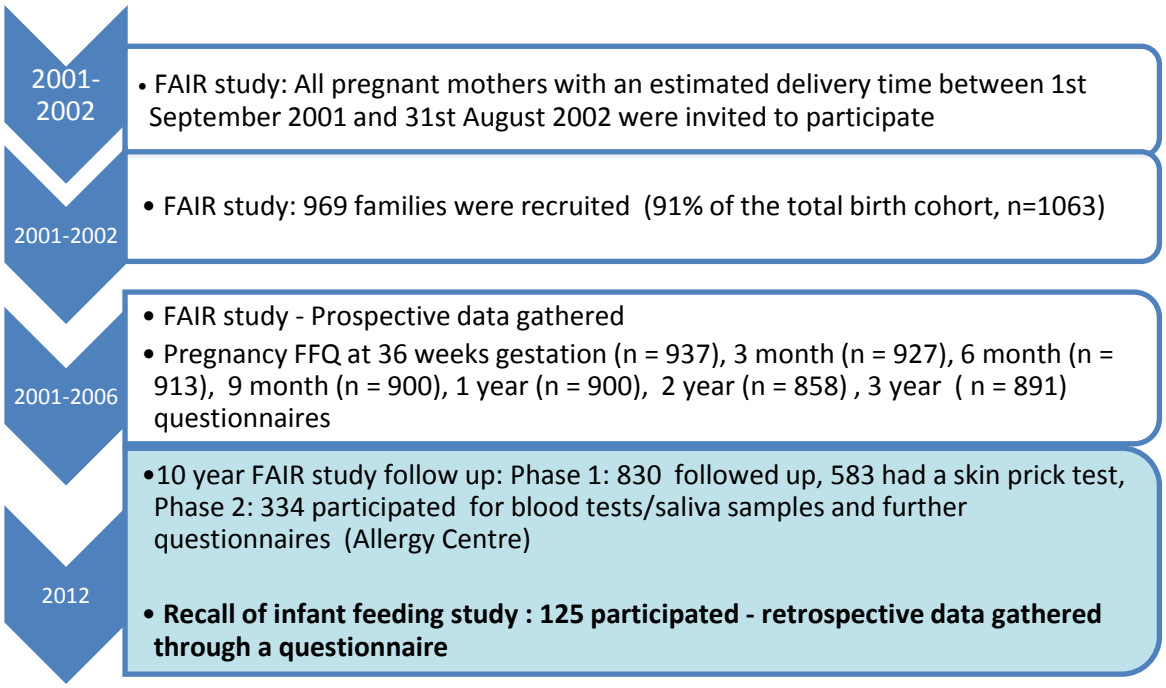

Figure 1 Flow diagram of study population from recruitment

Questionnaires

The 2001/2002 questionnaires used at 3, 6, 9 and 12 months consisted of questions relating to dietary intake when pregnant [25], breast feeding practices in terms of exclusivity and duration, age of introduction of formula and specific weaning foods and dietary avoidance. Mothers were not informed that they would be answering some of these same questions at any point again in the future. The questionnaires were tested for face validity by checking the understanding of the questions with a separate group of mothers. Criterion-related validity took place by comparing answers with those charted in participants' personal child health record (also known as the child's "red book"). The personal child health record is given to parents/carers at a child's birth in the United Kingdom and is the main record of a child's health, growth and development. Answers from the 2001/2002 questionnaire are used as the 'gold standard' for comparison of the answers from the current (2012) feeding questionnaire. At the 10 year follow up study in 2012, parents were asked to complete a feeding questionnaire consisting of 18 of the same questions which were asked in 2001/2002.

Sample

Non-random, purposive sampling was used. All parents of the 969 children who participated in the original FAIR study (a non-selective group) and who attended the FAIR clinics during the 10 year follow-up were asked to take part. Parents/carers attending the clinic who did not complete the original feeding questionnaires were not included in the study. The sample size was calculated using power analyses for repeated measures experiment. The sample size for this study was calculated using power analyses for repeated measures experiment, which in this case equalled two repetitions. A paired t-test was used for this purpose. Power analyses were done yielding 90% power with a Cohen's D of 0.298. In order to detect the smallest standardised effect, a sample size of 121 was set as the minimum for this study.

Ethical considerations

Ethics approval was obtained from the NRES Committee South Central in Southampton, UK, for the larger FAIR follow-up study (10/H0504/11) and the study of recall bias. Ethical approval from the Health Research Ethics Committee of Stellenbosch University, South Africa was obtained (S12/01/002) for the study investigating the impact of recall on the accuracy of dietary information.

This study and the preparation of the manuscript complies with STROBE guidelines for transparent and accurate reporting of observational studies.

Data analysis

Data was entered into SPSS, then exported to MS Excel and STATISTICA (StatSoft Inc. [2012] STATISTICA, version 11). Descriptive statistics and frequencies were calculated. Accuracy or agreement of recall in all cases, unless specified otherwise, was calculated by testing for the agreement of the answer given in 2012 to the 'gold standard' answer given in 2001/2002, based on a significant p-value < 0.05. The criterion for agreement was against the precise answer given in 2001/2002. The kappa coefficient and 95% confidence intervals were computed to measure the agreement before and later for categorical 2 x 2 responses (e.g. Yes/No). Sensitivity and specificity tests were used to compute the 'true positive' and 'true negative' for 2 x 2 tables where the answer was dichotomous.

Results

Participant recruitment and demographics

There were 830 participants recruited for the 10 year FAIR follow up study; of which 334 attended the allergy centre for an appointment. Of these 334 participants, 125 took part in the dietary recall study. Table 1 shows participant demographic characteristics.

Variable	
Mean age of child (years)	10.5 (SD 0.32)
Gender (n)	60% male (75)
Mean maternal age at child's birth (minimum-maximum)	30.2 (19-43)
Maternal education level (n)	0.8% did not finish school (1) 33% School (41) 52.4% Further education (66) 13.7% Higher education (17)
First born (n)	46% (58)
Ever had eczema	31.6%
Ever had hayfever	27.6%
Maternal asthma	21.5%
Maternal eczema	28.6%
Maternal hayfever	37.8%
Maternal food allergy	13.3%
Sibling with food allergy (n)	19% (13)
Diagnosed to food allergy using DBPCFC at age 1 (n)	1.6% (2)
Diagnosed to food allergy using DBPCFC at age 2 (n)	0.8% (1)
Diagnosed to food allergy using DBPCFC at age 3 (n)	1.6% (2)

Table 1. Participant demographic characteristics. DBPCFC: Double Blind Placebo Controlled Food Challenge

Accuracy of recall of breastfeeding

Ninety three per cent (114/123) of mothers reported accurately that they had breast fed (kappa coefficient 0.79, 95% CI 0.63-0.90). The specificity of recall was 100% (i.e. mothers reported not to have breastfed were 100% accurate in the pre and post questionnaire). The sensitivity of breastfeeding recall was 91% meaning 9% of mothers who did breast feed reported not to have breast fed.

There was substantial agreement between the answers reported in 2012 for duration of any breastfeeding and those reported 10 years earlier ($r = 0.84$, $p < 0.05$). In terms of duration of *exclusive* breastfeeding, a strong significant correlation was found between the answers over 10 years ($r = 0.70$, $p < 0.05$).

Accuracy of recall of formula feeding

The percentage of accurate answers to whether a child had a bottle of formula milk whilst in hospital was 84% (103/123) (kappa coefficient 0.67, 95% CI 0.54 – 0.80. Ninety four per cent (116/124) of mothers recalled accurately that their child had received formula milk at some stage, irrespective of when and how much. The specificity of the answers over this time period of recall was 95.7%. The sensitivity was 62.5%; therefore 37.5% of mothers recalled that their child had some formula milk even if they did not 10 years earlier.

There was a substantial agreement in the reported age at which mothers introduced formula milk ($r = 0.63$, $p < 0.05$). The trend for both the gold standard answer in 2001/2002 and the reported answer in 2012 was for fewer mothers to introduce formula milk as time went on. Some mothers recalled introducing formula milk after their child was a year old, although this was not the case 10 years earlier.

Mothers who had given formula milk to their baby were asked to recall which formula milk was given. Only 17/125 (13.6%) mothers answered this question. Fifty nine per cent (11/17) recalled the exact brand name over this 10 year period. Forty one per cent (7/17) of mothers recalled accurately the exact variant of the brand of formula milk. Neither of these results are statistically significant due to low numbers.

Accuracy of recall of solid food introduction

Timing of solid food introduction

Mothers were asked an open question about how old (weeks) their child was when first given solid foods. There was weak agreement between the two periods of reporting (r = 0.16). Figure 2 shows the distribution of answers from the mothers in 2001/2002 and 2012. The average age answered was 14.93 (SD = 2.48) weeks and 15.56 (SD = 4.57) weeks for 2001/2002 and 2012 respectively, showing that the answers in 2012 varied more than those in 2001/2002. More mothers recalled to have weaned earlier than they actually did. 76% of mothers could accurately remember when they first gave solid foods to their child within a four-week margin.

Type of solid food introduced

Mothers were asked an open question to determine which first three baby foods were introduced at weaning. A food was either categorised as a standalone food item or a food group, based on the categories set for the FAIR study[28]. Fifty three per cent (n = 66) of mothers were able to recall two or more of the foods/food groups accurately, leaving 47% who recalled one or no foods/food groups accurately. Rice, non-citrus fruit/juice and vegetables (not potato or tomato) were the most common foods/food groups that were accurately recalled. 87% (101/116) of mothers recalled correctly whether they had given their child commercial baby foods 10 years earlier.

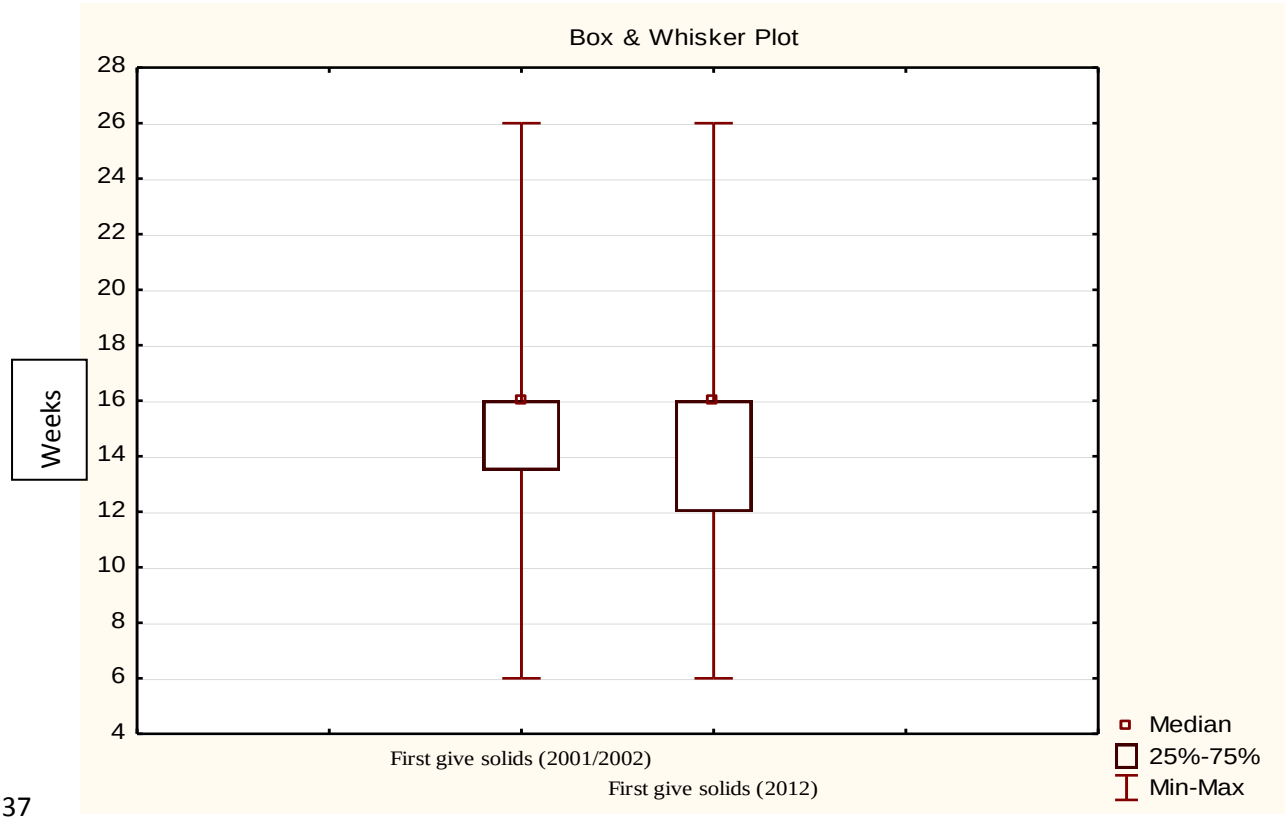

Figure 2 Recall of when solid foods were first introduced

Introduction of allergenic foods

Mothers were asked the age of their child when they first introduced some major food allergen groups into their diet. Each major food allergen group was listed with an option for mothers to select a categorical age range of introduction (< 3 months, < 6 months, < 9 months and > 9 months). Table 2 shows the number and percentage of mothers that recalled correctly when they first introduced certain allergenic foods into their child's diet. Most foods were poorly recalled, apart from peanuts which showed 86% accuracy.

Table 2 Number and percentage of correct answers for introduction of allergenic foods/food groups in 2001/2002 and 2012

At what age did you introduce the following foods into your child's diet?	
Allergenic food group options	**% accurate (n)**
Wheat containing foods (e.g. baby rusk, baby cereals, cereals, pasta, bread, cakes, biscuits)	44.8 (52/116)
Dairy foods (e.g. yoghurt, fromage frais, custard, ice cream, butter, margarine, cow's milk in food, cheese)	50.9 (59/116)
Fish	34.5 (30/87)
Whole egg	30.8 (28/91)
Soya	34.5 (10/29)
Tree nuts – almonds, brazil nuts, pecan nuts, hazel nuts, walnuts etc. (e.g. in chocolate, crunchy nut cornflakes, choc chip cookies, pesto sauce, vegetarian meals)	66 (51/77)
Peanuts (e.g. Bombay mix, peanut butter, peanut	85.7 (72/84)

Food avoidance

Asking mothers to recall 10 years later whether they excluded any foods from their child's diet when their child was six months was not at all accurate (kappa coefficient 0.09 CI 0.07 – 0.27). The specificity of the answers from the mothers in 2012 is 54.5%. Nearly half of mothers who

253 therefore reported ‘No’ to avoiding food items were incorrect. The sensitivity was computed
254 to be 54.5%; therefore just under half of mothers who reported that they did avoid food items
255 10 years earlier did not. From those mothers that were avoiding any foods, they were asked
256 again which specific foods were avoided. Out of the seventy nine accounts of avoidance, 40.5
257 % (32/79) of the recalled food/food group matched the answers given 10 years earlier.

258 **Recall of peanut consumption during pregnancy and in early childhood**

259 Mothers were asked about their consumption of peanuts at 36 weeks gestation and their child’s
260 consumption when they were two and 10 years old. Both the two-year and 10 year
261 questionnaires also allowed for parents to provide an answer of why they avoided giving
262 peanuts. The answers recalled by mothers from 36 weeks gestation to two years were shown
263 to be substantially agreeable (k = 0.64 CI 0.50 – 0.77). The agreement between mother’s
264 answers in 2012 from eight years earlier in 2003/2004 was 0.39 (CI 0.25 – 0.53), which is
265 considered fair agreement.

266 **Birth order and accuracy of recall**

267 There was stronger agreement for recall of whether they breast fed or not for mothers of
268 children who were born second or later compared to those for first born children (r = 0.85
269 versus r = 0.62 respectively). There was substantial agreement for the reported duration of BF
270 in all groups, irrespective of whether mothers were recalling for firstborns or children born
271 second or later. A similar pattern was noted for introduction of formula, with mothers of
272 children who were born second or later tending to provide more reliable answers than mothers
273 of first born children.

274

Discussion

To our knowledge this study is unique as it is the first to demonstrate dietary recall bias in a food allergy cohort, it captures data from maternal diet pre pregnancy through to advanced stages of weaning and it specifically addresses recall bias in the age of introduction of allergenic foods. This study using longitudinal, descriptive cohort data with a retrospective analytical component was designed to explore recall bias relating to infant feeding practices over a 10 year period. Data on breast feeding and infant feeding practices was collected prospectively from mothers in the FAIR study [21] and the accuracy of recall was tested by asking some of the same questions 10 years later. The results showed that it is reliable to ask mothers questions related to breast feeding and formula feeding over a 10 year period. Less reliable is recall relating to introduction of solid and allergenic foods and whether certain foods were excluded from a child's diet during weaning.

In agreement with previous research of breast feeding recall over a 15 or 22 year period [12,13,16], the present study confirmed that asking a mother whether she breast fed her child after 10 years is highly reliable. Natland *et al*.[13] specifically reported that close to 100% of mothers in Norway at the time were likely to have breast fed, even if for a week, therefore the strong accuracy of recall may not be entirely applicable to populations where BF rates are lower. Surprisingly in this study, results showed a sensitivity of 91%, meaning there were some mothers who breastfed that did not recall breast feeding. As the majority of mothers in the study breast fed for up to 1 month, it could be that some mothers didn't feel that the short duration of breast feeding justified a 'yes' answer. We also found that it is highly reliable to ask a mother to recall over 10 years how long she breast fed for and whether exclusively or not. The influence of the duration of breast feeding has been investigated for many health outcomes such as adult intelligence [29,30], obesity [3,31], diabetes risk [32], serum cholesterol [33], and blood pressure [34] and for aspects of maternal health including risk of breast cancer [35], ovarian cancers [36] and osteoporosis [37]. Due to the prolonged latency period between exposure and outcome, it is imperative to assess the validity of studies investigating the accuracy of recall over long periods. Although some long term recall studies reported good accuracy [8,12,13], other studies with a shorter duration of recall did not find this question as reliable [9,11,14].

It is suggested that in case control studies cases are more likely to remember past exposures owing to concern about their condition [5]. Cows' milk allergy (CMA) often presents when formula milk is introduced. An assumption could therefore be made that mothers of

children with CMA are more likely to accurately recall when they first introduced formula milk into their child's diet compared to mothers of children who were not allergic to milk. We are not aware of any studies that have examined whether accuracy of recall of infant feeding practices is affected by a diagnosis of allergy in the child the recall is based upon. Unfortunately, due to low numbers of food allergic children, no significant conclusions could be drawn from this study. Overall recall of timing of introduction of formula was reliable, with 84% of mothers accurately recalling whether her child received a bottle of milk formula within the first 1-2 days of birth. This is noteworthy as intervention studies have previously reported that infants exposed to cows' milk formula in hospital immediately after birth have a higher risk of developing CMA compared to those fed pasteurised human milk, whey hydrolysate formula or are exclusively breastfed [(2)].

The timing of introduction of solid and allergenic foods is a matter of significant debate in the allergy field. Advice for parents/carers has changed over time as research in this area has been conflicting [(18,20,38)]. The age at which solid foods were introduced into the diets of infants was poorly recalled by mothers. There was a tendency for mothers to report that they weaned earlier than they did a decade earlier, although there were also some mothers that reported to wean much later too. Previous studies investigating the accuracy of recall of the introduction of certain foods over time periods from 1-22 years also reported poor accuracy [(8,12,14)]. One study [(14)] acknowledged that a poorly constructed question was used; "When did you stop breast feeding" as the measurement for duration of breast feeding and time point when solid food was introduced. This underlines the importance of constructing a question appropriately to ensure that it extracts the answer it is intending to and making a clarification between exclusive breastfeeding and any breastfeeding.

Overall the recall of age of introduction of allergenic foods was poor, with the exception of peanuts. There was also a very poor agreement as to whether any foods were excluded from the child's diet at the age of six months ($r = 0.09$). Gustafsson *et al.* [(39)] studied the impact of age of weaning and introduction of certain food allergens on the risk of the development of sensitisation and clinical allergy, relying on a recall period of up to 3 years. Based on the results of this study, their outcomes should be interpreted with caution. Two studies [(40,41)] that investigated the relationship between the timing of the introduction of peanuts and the development of peanut allergy relied on mothers to recall details up to two and three years later. Results of the present study, demonstrating that 86% of mothers recalled correctly the

timing of peanut introduction over an assessment period of 10 years, would suggest that recall of the timing of peanut introduction over 2-3 years should be reliable.

Food allergens cross the placenta from a mother to her child during pregnancy [42]. Results of a study that investigated the exposure of peanuts during pregnancy and the prevalence of peanut allergy [43] contributed to the development of national guidelines for pregnant mothers of high risk infants to avoid peanuts during their pregnancy [24]. This study relied on mothers reporting whether they consumed peanuts during pregnancy when their children were up to 18 years of age. Further studies by Dean *et al*. [44] and Hourihane *et al*. [23] were commissioned by the Food Standards Agency in order to investigate whether the guidance on peanut avoidance was being followed by the target group and whether it was having an impact on the prevalence of peanut allergy in the UK. Hourihane and colleagues reported no reduction in the prevalence of peanut allergy and only 3.8% of the mothers interviewed had followed the advice of stopping the consumption of peanuts during pregnancy, although this study relied on mothers recalling 5-6 years earlier whether they had avoided peanuts or not. According to this study, research examining the association between maternal consumption of peanuts and the development of peanut allergy can rely on mother's recall up to two years post pregnancy, but recall of maternal peanut consumption over a period of eight years was shown to be unreliable. These findings however, used recall at two years of age as the gold standard for comparison. Although results showed that answers up to two years are reliable, the level of agreement ($r = 0.70$) was not perfect. The 'gold standard' answer that the 8-year recall answer is assessed against is therefore not 100% accurate.

Unlike the majority of existing studies that have assessed the accuracy of recall of infant feeding practices, this study also explores the duration of EBF, the introduction of solids and allergenic foods on recall bias. Participation bias cannot be ruled out as recall data was collected for 125 out of the 969 mothers; however recruitment stopped once adequate numbers for power were reached. It is possible that social desirability bias may have influenced the response to questions at either time points and that this influence could have changed over time. Time points were only explored at 36 weeks gestation, first year, second year and 10 years, and hence recall bias at other intervals could not be assessed. Whilst the study involved a good sample size, it was not sufficiently powered to explore bias in those specifically suffering from food allergy. Although the population on the Isle of Wight is reflective of the population in the South of England, the results of this study need to be interpreted with caution in populations that are dissimilar.

Conclusion

The results of this study show that the accuracy of maternal recall over a 10 year period varies considerably according to the specific aspect of infant feeding being recalled. Recall of answers related to breast feeding and formula feeding agree substantially over these two time points. Whether commercial baby food was provided and the age of introduction of peanuts into a child's diet 10 years earlier is well recalled, however other aspects of introduction of solid foods is poorly recalled. Mothers recalled avoiding peanuts during pregnancy well over the two year period after birth, but a further 8 years on, peanut avoidance during pregnancy was not so well-recalled. Whether a family history of atopy/allergy or diagnosis of food allergy in the infant influences the ability to accurately recall infant feeding practices warrants further exploration, but a larger study population will be needed. Studies that use a retrospective collection of dietary data design need to carefully consider the strength of recall bias when interpreting results.

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