Exploring nutrient and energy intake in infants weaned using a baby-led or traditional feeding style

Hannah Rowan

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Summary

Baby-led Weaning (BLW), where infants self-feed whole foods rather than being spoon fed pureed foods, has grown in popularity over the last decade. Proponents of the method believe that BLW improves weight trajectories and food acceptance due to the infant being in control of how much they eat and the focus on whole family foods, but there has been sparse research on the efficacy of the method, raising concerns amongst health professionals and impeding the support offered to families. The majority of the research conducted has focussed on weight trajectories, with most conducted outside of the UK. Therefore, using four studies, the aim of this thesis was to examine energy and nutrient intake amongst infants aged 6– 12 months following a baby-led versus spoon-feeding approach. The first study used an open-ended questionnaire to explore the experiences and concerns of 68 UK health professionals around BLW. Nutrient intake and eating behaviour was then compared for infants following BLW and spoon-feeding in 3 studies. The second (n=297) utilised a questionnaire to compare food intake, preferences and eating behaviours. The third (n=180) compared a 24 hour recall, while the fourth (n = 71) analysed detailed nutrient and energy intake using a three day weighed food diary. Overall, BLW infants were perceived to have greater satiety responsiveness and food acceptance. They consumed a wider variety of vegetables and protein rich foods and ate fewer commercial products. Differences were more pronounced at the start of weaning, with BLW infants having a more gradual transition to solid foods. Notably no difference in consumption of iron rich foods was found with iron intake below recommendations in both groups. The research does have limitations but suggests that BLW can provide sufficient energy and nutrient intake and may be a way of fostering positive eating behaviour.

Declarations and Statements

DECLARATION

This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

Signed .... [redacted].......... (candidate)

Date ....4/1/2021..

STATEMENT 1

This thesis is the result of my own investigations, except where otherwise stated. Where correction services have been used, the extent and nature of the correction is clearly marked in a footnote(s).

Other sources are acknowledged by footnotes giving explicit references. A bibliography is appended.

Signed .... [redacted].................. (candidate)

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STATEMENT 2

I hereby give consent for my thesis, if accepted, to be available for photocopying and for inter-library loan, and for the title and summary to be made available to outside organisations.

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Acknowledgments

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I'm also thankful to the mums, dads and babies who took part in this research, especially those who completed the three day diet diary: your hard work retrieving leftovers from bibs and high chairs went above and beyond!

Finally I would like to acknowledge my family's part in this: for Pete's encouragement to keep going when I wanted to quit, and for Thea, who was my first reason "why".

List of Tables and Figures

Abbreviations

AHEI Alternative Healthy Eating Index

ALSPAC Avon Longitudinal Study of Parents and Children study

BAME Black Asian and Minority Ethnic

BeeBOFT Breastfeeding, breakfast daily, outside playing, few sweet drinks, less TV

BLISS Baby-Led Introduction to SolidS

BLW Baby-led weaning

BMI Body Mass Index

CASP Critical Appraisal Skill Program

CEBQ Child Eating Behaviour Questionnaire

CINAHL Cumulative Index to Nursing and Allied Health Literature

COFIDS Composition of Foods Integrated Dataset

DARLING Davis Area Research on Lactation and Growth study

DHA Docosahexaenoic Acid

DHSC Department of Health and Social Care

DNSIYC Diet and Nutrition Survey of Infants and Young Children

DONALD Dortmund Nutritional and Anthropometric Longitudinally Designed

DQI Dietary Quality Index

EAR Estimated Average Requirement

EPA Eicosapentaenoic Acid

FITS Feeding Infants and Toddlers Study

GEMINI UK twin study

GWAS Genome Wide Analysis Study

HCP Health Care Professional

HEI Healthy Eating Index

HELENA Healthy Lifestyle in Europe by Nutrition in Adolescents

HSE Health Survey for England

IDA Iron Deficiency Anaemia

INSIGHT Intervention Nurses Start Infants Growing on Healthy Trajectories

LAUNCH UK family-based obesity intervention study

MC4R Melanocortin 4 Receptor

NCMP National Child Measurement Programme

NDNS National Diet and Nutrition Survey

NHANES National Health and Nutrition Examination Survey

NHS National Health Service

NOURISH Australian infant feeding RCT

PHE Public Health England

POMC Pro-opiomelanocortin

PROP 6-n-propylthiouracil

PSDQ Parenting Styles and Dimensions Questionnaire

QUALITY QUebec Adipose and Lifestyle InvesTigation in Youth

RDA Recommended Dietary Allowance

RNI Reference Nutrient Intake

RWG Rapid Weight Gain

SACN Scientific Advisory Committee for Nutrition

SES Socio-economic Status

SNIPS Single Nucleotide Polymorphisms

TMBQ Toddler Parent Mealtime Behaviour Questionnaire

TSF Traditional Spoon Feeding

TW Traditional Weaning

UPF Ultra Processed Foods

WHO World Health Organisation

Chapter 1: Introduction

At around six months of age, infants need to start to make the transition from a milk-based diet towards eating family foods (WHO, 2001). Historically infants were offered family foods from around 9 months of age, sometimes spoon-fed in mashed form and sometimes given as finger foods to self-feed. However, industrial changes in the 1930s led to the birth of the 'baby food industry' where a series of products were invented to give to babies during the complementary feeding period. As the market expanded, the age at which babies were introduced to solid foods grew earlier and earlier, with many infants receiving solid foods as early as six weeks old by the 1950s. The developmental abilities of a 6-week-old infant meant that foods given had to be very smooth and delivered via a spoon (Bentley, 2014). Gradually this came to be seen as the 'normal' way to introduce solid foods to babies, although it should be stressed no research was conducted as to the safety and efficacy of these products and methods (Rapley and Murkett, 2008).

Fast forward fifty years and not only do we have a better evidence base of the importance of waiting until around six months to introduce solid foods (WHO, 2001), but the tide has started to reverse in terms of how babies receive these. Increasing numbers of parents are now following a 'new' approach known as baby led weaning (BLW). Here infants self-feed family foods in their whole form rather than following the 'traditional' approach of being spoon-fed soft, pureed baby foods. Parents who follow the BLW method often believe it has several benefits for infants, including supporting healthy weight trajectories, a more positive relationship with food, and healthier dietary patterns (Brown and Lee, 2013; Cameron, Heath, & Taylor, 2012a; D'Andrea, Jenkins, Mathews, & Roebothan, 2016). However, research supporting these beliefs is sparse, and often conducted in countries outside of the UK.

Understanding the impact of the BLW approach upon nutrient intake and growth is an important area of research for several reasons. First, if this approach does support healthier outcomes then it may have important lessons for how we support parents in introducing their baby to solid foods. Childhood overweight and obesity is a major public health issue in the UK with almost 10% of 4-5 year old children in the UK already obese, with another 13% being overweight (NHS, 2019b). Understanding the drivers of problematic weight trajectories in children continues to be a research priority, with increasing attention turning to the very earliest influences on weight and eating behaviour trajectories. Although much of the research focuses on overconsumption of energy, nutrient intake and diet quality is a core part of this relationship. Fussy eating, limited diet variety and nutrient poor food choices are closely linked to overweight and obesity alongside other health issues (Finistrella et al., 2012; Robson et al., 2019; Setayeshgar et al., 2017).

Obesity, diet quality and eating behaviour are multi-factorial issues in origin, encompassing genetic, social and environmental factors. However, attention has turned more recently to children's earliest experiences with food, including how they transition to solid foods. There is emerging evidence that along with weight, a child's earliest food preferences and eating behaviours can track into adolescence and adulthood (De Cosmi, Scaglioni, & Agostoni, 2017; Nicklaus, Boggio, Chabanet, & Issanchou, 2005; Simmonds, Llewellyn, Owen, & Woolacott, 2016; Ventura and Worobey, 2013). This has highlighted the importance of a child's formative relationship with food to the development of their taste preferences, food acceptance and satiety regulation, concurrent with their first tastes of solid foods during the complementary feeding period.

Research examining the association between early feeding experiences and later weight and eating behaviour has tended to focus on milk feeding (Bartok and Ventura, 2009; Brown and Lee, 2012) or the timing of complementary feeding, (Arora et al., 2020; Barrera, 2018; Doub, Moding, & Stifter, 2015). The (re)-emergence of BLW as a method of introducing complementary food poses important questions for how this may affect infant weight, appetite and nutrient intake. However there has been little research comparatively examining these outcomes, especially in a UK context. Where research has been conducted it has focused primarily on the experiences of mothers using the method or perceived infant eating behaviours compared with how this impacts upon infant diet or nutrient intake. Although some research has explored weight outcomes for different complementary feeding approaches, these typically have more of a focus on weight as the primary outcomes as opposed to the nutrient intake that may have affected it (Brown, Jones, & Rowan, 2017).

This leads to an interlinked rationale for conducting research into the impact of BLW. This lack of research means that developing evidence based guidelines to support parents in feeding their infant is a challenge. Although as noted above, no evidence was required to start feeding an entire generation of infants on commercial pureed infant foods, reversing the process is perceived to require evidence with the UK Department of Health stating a dearth of evidence as a reason for not officially supporting the method. Indeed, the recent Scientific Advisory Committee on Nutrition (SACN) report 'Feeding in the First Year of Life' acknowledges the method but also states more research into its efficacy and safety is needed (SACN, 2018). This lack of research affects the ability of health professionals to support parents who have chosen to follow the method. Qualitative research in Canada and New Zealand with health professionals highlights a lack of knowledge, training and concerns around whether the method is safe and provides sufficient nutrient and energy intake, which in turn affected their practice in supporting parents (Cameron et al., 2012a; D'Andrea et al., 2016).

However, parents need to be supported. Although official figures on how many parents are following a BLW have not been collected, a google scholar search of 'baby led weaning' now brings up over 1200 hits (30.12.2020), with membership of online baby led weaning support groups on social media having in excess of 100,000 members. Given UK Department of Health Guidelines do recommend the inclusion of finger foods from the start of the complementary feeding period and that self-feeding is an important developmental skill, there should be little issue in the safety of a method based on self-feeding and finger foods. However, the question arises as to whether an approach based solely or at least predominantly on this allows infants to receive sufficient nutrient and energy for their growing needs.

At the time of starting this thesis no research had been published globally on this topic. During the thesis, two randomised controlled trials in New Zealand and Turkey were conducted including nutrient and energy intake measures but at the time of submission this thesis remains the only UK study to accurately measure differences in nutrient intake amongst BLW and spoon-fed babies.

Aims of this thesis

The aim of this thesis was therefore to explore how a baby led weaning approach compares to spoon-feeding in terms of its impact upon infant eating behaviour, food preferences, energy and nutrient intake. Specifically, five research questions were developed to explore this overarching aim, with four interlinked studies designed to examine these:

Research questions:

R1. Do UK healthcare professionals have concerns about dietary intake and weaning approach?

R2. Does eating behaviour and food acceptance differ between weaning groups?

R3. Are there differences in energy intake between weaning groups?

R4. Are there differences in macro/micronutrient intake between groups?

R5. Is BLW sufficient or significantly different to traditional weaning?

This thesis is presented in seven chapters providing a literature review, four self-contained research study chapters and a general discussion bringing the work together. For ease of reference, a schematic representation of the studies can be found on page sixteen of this chapter.

- **Chapter 2** presents a narrative review of the literature around the impact of childhood overweight, nutrient intake and eating behaviour, focusing on early life factors, specifically how infants are introduced to solid foods. The review then turns to the implications of infant feeding practices such as baby-led weaning and what is known about their potential consequences to health and long-term eating habits.

- **Chapter 3** offers a qualitative exploration of the attitudes and opinions of 68 health and child care professionals around baby-led weaning. The sample comprised public health workers such as health visitors (n=36), lay supporters such as breast feeding advisors (n=13), child care and nursery workers (n=7), medical professionals (n=6) and nutrition specialists (n=6).

- **Chapter 4** details a survey, including a Food Frequency Questionnaire, of the dietary patterns and eating behaviours of infants aged 6-12 months using different weaning styles, in a sample of n=297 parents. Infants were divided into three age groups (6-8, 9-10 and 11-12 months) and three weaning groups: strict BLW, loose BLW and traditional weaning.

- **Chapter 5** outlines the results of a 24 hour recall of a subset of 180 parents from the previous sample, comparing infants aged 6-12 months in three age-groups and using three different weaning methods as previously described.

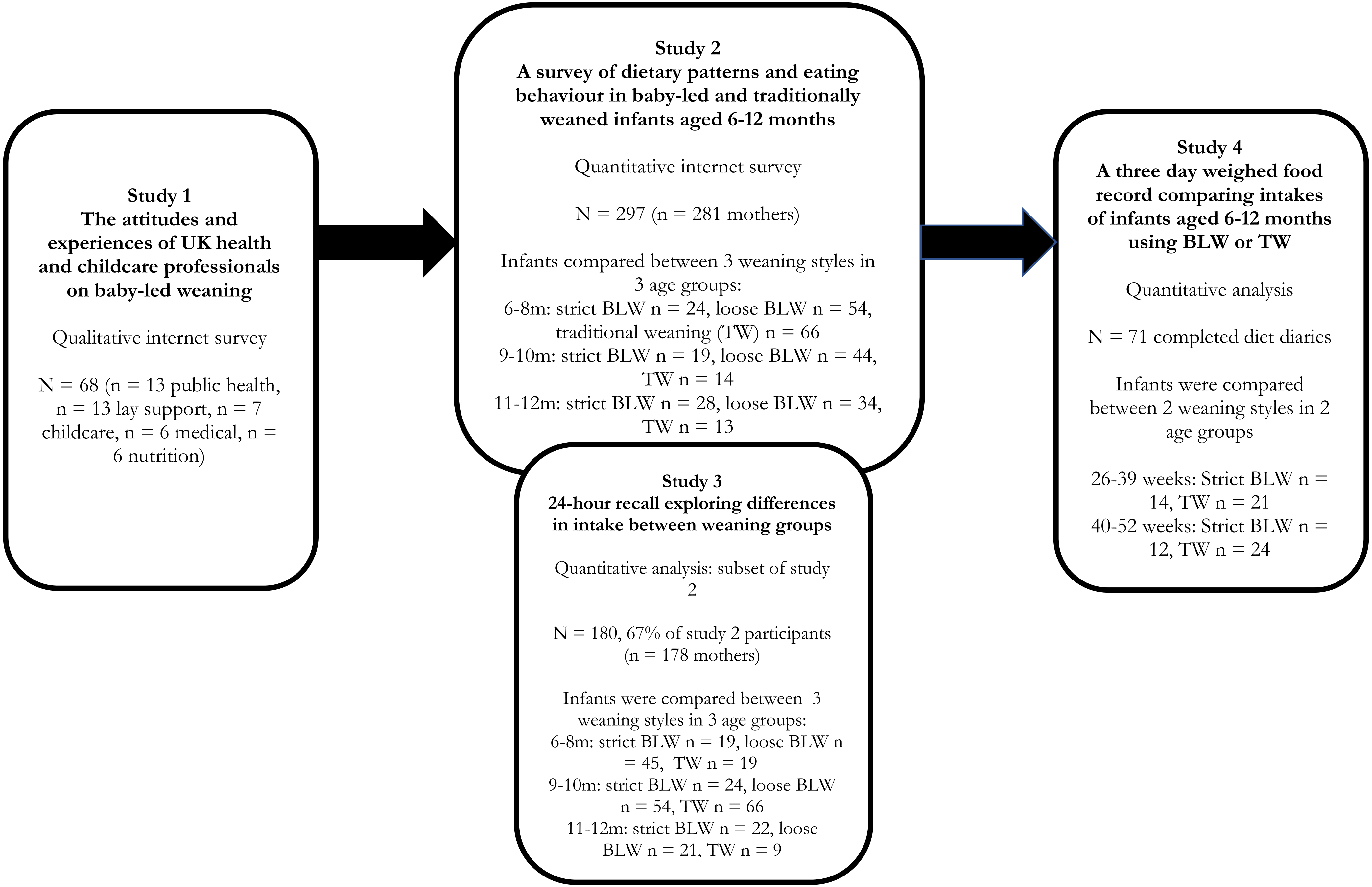
- **Chapter 6** presents a 3 day diet diary comparing energy and nutrient intakes of 71 infants aged 6-12 months, divided into two age groups (6-8 and 9-12 months, n=35 and n=36 respectively) and two distinct weaning groups – strict BLW (n=26) and traditional weaning (n=45).

- **Chapter 7** brings together the findings of this thesis in a general discussion.

Terminology used in this thesis

For clarity, in this thesis the term "weaning" is used synonymously with the phrases "introduction to solid foods" and "complementary feeding" to describe an infant's journey from being fed solely by milk (breast or infant formula), to eating a family diet at around 12 months of age, when nutrition from milk is no longer a requirement. The decision was made to use these words interchangeably to convey the same meaning because phrases such as "complementary feeding" tend to be used in policy documents, whereas health professionals often refer to the more colloquial "starting solids". However parents appear to often use the word "weaning" which has become part of the phrase "baby led weaning". It is recognised that in some cultures, particularly in the US, "weaning" refers to the act of stopping breastfeeding but this term is less frequently used in the UK where the data was collected.

Figure 1: Schematic of studies within this thesis



Chapter 2: Literature Review

This chapter presents a narrative review of the literature surrounding childhood overweight, nutrient intake and eating behaviour, focusing on early life factors, specifically how infants are introduced to solid foods.

2.1 Literature search

To conduct the initial review in 2014, a detailed search of the literature was performed, using key terms around infant nutrition, eating behaviour and weight (see below). Later searches were conducted as the thesis progressed, to ensure the latest research around baby-led weaning was included in the review. Search engines used included Google Scholar, PubMed and the Cochrane library. Given the nature of the research, a search of government guidance and policy documents was also conducted via the UK Department of Health and Social Care (DHSC), Public Health England (PHE), Scientific Advisory Committee on Nutrition (SACN) and the World Health Organisation websites.

Key terms searched included: child obesity; child weight; child nutrition; child eating behaviour; infant weight; infant nutrition; infant eating behaviour; satiety responsiveness; fussy eating; picky eating; neophobia; first year of life; infants; mothers; breastfeeding; formula feeding; starting solids; introduction of solids; complementary feeding; weaning; spoon-feeding; baby led weaning; baby-led; child led feeding; nutrient intake; diet diary; dietary assessment methods; infant food preferences and infant food enjoyment.

Papers were included if in the English language. Publications were included from all regions, paying careful attention to context and guidelines around infant nutrition and introducing solid foods. No date limitations were placed on papers included, although careful consideration was given to older research including considering whether updated research had been published. Some older papers were included due to being seminal research on the topic, with significant levels of citation. By the nature of the research question, all studies related to baby-led weaning were published within the last decade.

To ensure inclusion of only high-quality papers, critical reading was guided by the principles of CASP (2013). Identified abstracts were assessed for relevance in terms of content, and then critically analysed in terms of methods and sample included. Owing to the paucity of research on the topic of baby-led weaning, the vast majority of papers on the topic were included in this review. These originated from research conducted in developed countries, primarily the UK, New Zealand and Canada. Two papers were excluded: one investigating the gut microbiome in BLW infants, which was deemed to lack relevance to intake and eating behaviour (Leong et al., 2018), and a second study from Turkey in which some of the reported results did not match those highlighted by the authors, which although could have been due to errors in translation, meant the study's conclusions lacked integrity (Kahraman, Gümüş, Binay Yaz, & Başbakkal, 2020).

2.2 Childhood overweight and obesity

Child overweight and obesity is an issue that has received attention in the media for many years, after prevalence started to rise steadily in the 1980s (Abarca-Gómez et al., 2017). It is a discrete risk factor for overweight and obesity in adulthood and correlates with the development of chronic diseases such as diabetes and cardiovascular disease later in life (Baker, Olsen, & Sorensen, 2007; Freedman et al., 2008; Serdula et al., 1993). As well as physical health outcomes, childhood obesity has been linked to poor mental health often due to social exclusion and discrimination from both peers and teachers (Gunnarsdottir, Njardvik, Olafsdottir, Craighead, & Bjarnason, 2012; Puhl and Latner, 2007; Yanovski, 2015). Obesity in children has also been linked to lower academic attainment including in the ALSPAC cohort which found an association between obesity in adolescent girls and lower academic achievement and an Australian longitudinal study which found lower attainment in obese boys (Asirvatham, Thomsen, & Nayga, 2019; Black, Johnston, & Peeters, 2015; Booth et al., 2014). However, findings from one recent review were mixed (Martin et al., 2017) and the cause of the association was posited as due to social stigmatisation and a negative attitude to school due to bullying, rather than the direct effect of obesity on executive function, thus reinforcing the impact of obesity on mental health. Aside from psycho-social effects for the individual, obesity-related illness also has a financial impact and is expected to cost the NHS £9.7 billion by 2050, with added societal costs through absence from work and school of up to £49.9 billion (PHE, 2017).

Definitions of overweight and obesity differ between countries, but most rely on using BMI (Body Mass Index) as a measure of weight. BMI is a person's weight in kilograms divided by their height in metres squared. For example, a BMI of 25 is 25kg/m2. In children, BMI is measured similarly but also takes into account age and gender and measures BMI as a percentile against a reference population. For example, in the USA, an overweight child has a BMI at or above the 85th percentile but lower than the 95th percentile for children of the same age and sex, while obesity is defined as having a BMI equal to or greater than the 95th percentile (Barlow, 2007). In the UK, the same definitions above are used for population monitoring such as the National Child Measurement Programme, but for clinical purposes, a BMI between the 91st and 98th percentile is considered to be overweight and one at or above the 98th percentile constitutes obesity (Dinsdale, Ridler, & Ells, 2011)

The number of overweight and obese children under five has risen from an estimated 30 million worldwide in 1990 to 40 million in 2018 (WHO/UNICEF/WORLDBANK, 2019) and the links between obesity in children and chronic disease in adulthood have prompted the World Health Organization to rate child obesity as one of the 21st Century's most pressing health concerns. In the UK as of 2018-19, the latest data available from the National Child Measurement Programme (NCMP) which weighed over 1 million English children in their first year at school (NHS, 2019b), obesity prevalence in Reception classes (children aged 4-5 years with a BMI at or above the 95th percentile) increased to 9.7% in 2018/19 from 9.5% in 2017/18, but there has been a slight decrease since the initial survey in 2006/7, when the rate was 9.9% (NHS, 2019b)

When data from year 6 children (aged 10-11) were examined, obesity and severe obesity showed an upward trend with 17.5% being obese in 2006/7 and 20.2% in 2018/19, a similar figure to the previous year. However, the prevalence of obesity for children living in the most deprived areas was double that of those living in the least deprived areas for both reception and year 6, with prevalence of obesity at 13.3% for those in the most deprived areas against 5.9% for those children living in the least deprived areas. Severe obesity in children aged 4-5 years (defined as having a BMI at the 99.6-100th percentile) was almost four times as prevalent in the most deprived areas (3.9%), when compared to the least (1.0%). In children aged 10-11, prevalence of severe obesity was at 7.1% in the most deprived areas and 1.5% in the least.

Given the significant rates and impact of childhood obesity, understanding the origins and risk factors for its development and trajectory is an important public health priority.

2.2.1 Influences on childhood overweight and obesity: Behavioural Susceptibility Theory

Although becoming overweight or obese could appear to be a simple process of taking in more energy than one expends over a period of time, the aetiology of overweight and obesity is in fact multifactorial, and rooted in the relationship between the genetic profile, biology, environment, family and social group of the individual affected (Butland et al., 2007).

Although individual susceptibility to obesity is rightly discussed as a function of biology (for example, through genes and hormone systems, which are reviewed below in section 2.2.1.2), a person's appetitive behaviour around food has an important influence over their inherited predisposition to a particular weight, and given that we are all exposed to the same environment, yet not all are overweight or obese, it is clear that other factors are at play. Behavioural susceptibility theory (BST), first described by Professor Jane Wardle (Carnell and Wardle, 2007, 2008), partly explains individual differences in intake and weight when considered against the backdrop of our overarching obesogenic environment (discussed in section 2.2.1.3) . Wardle proposed that genetic differences in appetite were responsible for the differences observed in susceptibility to overweight when exposed to the same environmental conditions (Carnell and Wardle, 2007, 2008). She theorized that weight can be influenced by both genes and the environment concurrently, and that genetic expression of weight is greater in obesogenic environments because those who are more responsive to external and internal food cues are more likely to overeat when surrounded by opportunities to access highly palatable foods.

Wardle tested her hypothesis among children, whose internal appetite regulation is less likely to have been affected by experiences of dieting or physiological responses to obesity, by developing the Child Eating Behaviour Questionnaire (CEBQ). The CEBQ measures aspects of children's eating behaviour (as reported by parents), that are believed to influence weight trajectories, such as satiety responsiveness, enjoyment of food, fussiness and food responsiveness, and it has been shown to have good internal and external validity (Wardle, Guthrie, Sanderson, & Rapoport, 2001). Research using the CEBQ over the last 20 years has consistently shown that higher food responsiveness and enjoyment of food are associated with higher weight, while increased satiety responsiveness and slowness in eating are associated with lower weight (Llewellyn and Fildes, 2017). Thus, weight status has been linked with certain eating behaviours, underpinning the BST.

To clarify the direction of influence, Wardle created a prospective birth cohort study of twins (GEMINI), to look at bidirectional genetic and environmental effects on infant and childhood growth (Van Jaarsveld, Johnson, Llewellyn, & Wardle, 2010). The findings demonstrated that differences in appetitive behaviours observed at 3 months of age affected weight gain from 3 to 15 months, while further studies have confirmed the heritability of these eating behaviours and highlighted the likelihood that genes influence weight partly though their impact on appetite (Dubois et al., 2013; Faith et al., 2012; Herle, Smith, Kininmonth, & Llewellyn, 2020; Kan et al., 2020; Llewellyn, Trzaskowski, van Jaarsveld, Plomin, & Wardle, 2014).

Clearly then, genes have a role in appetitive behaviour, and therefore susceptibility to weight gain. However, although genes play a part, our environment, including access to high-energy food and socio-economic background, has also been found to be key by the GEMINI researchers (Kininmonth, Smith, Llewellyn, & Fildes, 2020). Mechanisms by which the food environment may influence or mediate heritable eating behaviors, such as family dynamics and early feeding experiences, are explored in this review of literature. Discussion of the obesogenic environment's influence on susceptibility to overweight starts in section 2.2.1.3.

2.2.1.2 Genetics, biology and weight homeostasis

The genetic associations with obesity introduced above are complex but can be divided into three main forms: single-gene syndromes, such as Prader-Willi syndrome, characterized by short stature, learning difficulties, hyperphagia and subsequent obesity (Butler, 2011; Cassidy and Driscoll, 2009), non-syndromic obesity and polygenic obesity (Kaur, de Souza, Gibson, & Meyre, 2017). Non-syndromic genetic obesity refers to mutations in specific genes such as those coding for POMC (Pro-opiomelanocortin) and MC4R (the melanocortin 4 receptor), both of which play a part in the body's system of satiety regulation. Dysregulation of their respective signaling pathways can lead to increased appetite and consequent weight gain (Candler, Kühnen, Prentice, & Silver, 2019; Nguyen and El-Serag, 2010). For example, defects in the leptin receptor gene were found in 3% of those with early onset obesity in one study (Farooqi et al., 2007), while leptin resistance has been found widely in adults with obesity (Nogueiras, Tschöp, & Zigman, 2008), in part because of leptin's links with the functioning of the MC4R gene which is key in regulating food intake and energy expenditure (Farooqi et al., 2003). Leptin is discussed further in the discussion of bodyweight homeostasis.

Polygenic obesity refers to the effect of multiple genetic alterations or Single Nucleotide Polymorphisms (SNiPs) (Kaur et al., 2017). Over a thousand obesity-related SNPs have now been identified using Genome Wide Analysis Studies (GWAS), including the first obesity-specific SNP identified on the FTO gene (Frayling et al., 2007). The FTO gene SNPs have been found to increase susceptibility to obesity by increasing food intake, increasing appetite and reducing satiety but not via activity levels (Loos and Yeo, 2014). In fact, in those with FTO mutations, physical activity may reduce susceptibility to obesity but the mechanism behind this remains unclear (Gong et al., 2021; Kilpeläinen et al., 2011).

In spite of the high number of genetic markers associated with obesity, only 4% of the variance in BMI has been accounted for with these specific genes (Locke et al., 2015; Pulit et al., 2018; Yengo et al., 2018). Given the effect of heritability on obesity is estimated to be between 40-90% in twin studies comparing monozygotic (identical) and dizygotic (fraternal) twins (Elks et al., 2012; Llewellyn, Trzaskowski, Plomin, & Wardle, 2013; Maes, Neale, & Eaves, 1997), investigations are targeting "missing heritability", the difference between the effect of specific genes on obesity and that seen in twin heritability studies (Hebebrand, Volckmar, Knoll, & Hinney, 2010; Llewellyn et al., 2013): as yet there is no consensus on its cause.

It is likely that the majority of the genetic impacts on weight are modified by our habits and environment, which overrides genetic predispositions to a certain BMI (Castillo, Orlando, & Garver, 2017). One recent twin study found the heritability of BMI at 4 years for those living in more obesogenic home environments was 86%, more than double that of children living in less obesogenic environments (39%) (Schrempft et al., 2018). This emphasises the importance of epigenetics, the interaction of our genes with the environment and socio-economic status, physical activity and access to energy dense food, meaning that although our genes set the stage, they do not tell the whole story (Cummings and Schwartz, 2003).

In addition to specific genes and genetic profiles linked to obesity, humans are born with a complex system of mechanisms including internal hunger and satiety cues to maintain body weight homeostasis. This system includes the hypothalamic regulation of appetite in response to energy stores, gastric satiety or hunger signals from the sight or smell of food, hormonal response to post-prandial digestion and the interplay of hormones like leptin and ghrelin. In particular the hormones leptin and ghrelin are known to affect appetite and eating behaviour. Ghrelin is produced in the gastro-intestinal tract, primarily in the stomach. It stimulates appetite and promotes fat storage and is produced ahead of meals, and falls afterwards in a cyclical manner (Berardi and Andrews, 2013; Nogueiras et al., 2008). Leptin, on the other hand, is produced in adipose tissue and suppresses appetite and increases activity.

There are several theories of weight homeostasis, including the set-point, settling point and dual intervention models (Hall and Guo, 2017; Müller, Geisler, Heymsfield, & Bosy-Westphal, 2018; Speakman et al., 2011; Weinsier et al., 2000). Set-point theory is perhaps the most well-recognised attempt at explaining how the body balances energy intake and expenditure and reflects many of the biological functions of energy balance (Kennedy, 1953). The theory describes a negative feedback loop of adiposity around a genetically determined target (set-point). For example, it explains why a person regains weight after a period of dieting and weight loss and the body defends its set-point. The theory was bolstered by the discovery of leptin, a hormone produced in fat tissue with receptors in the brain linked to energy balance regulation, providing evidence for how the feedback loop may work (Caro, Sinha, Kolaczynski, Zhang, & Considine, 1996). As body fat levels increase due to positive energy balance, leptin levels increase and alter feeding behaviour leading to a reduction in intake (Davis et al., 2011; Farooqi et al., 2007). Evidence for leptin's importance in energy balance has been demonstrated by the discovery of leptin gene mutations leading to obesity and hyperphagia (Farooqi et al., 2001; Farooqi and O'Rahilly, 2008).

However, set-point theory cannot explain the rise of obesity worldwide over the last forty years (Ezzati, 2017). If there was indeed a simple biological feedback mechanism that allowed humans to maintain a given weight, humans would not experience the steady increase in weight over a lifetime that is normal for many, nor would this explain why obesity disproportionately affects those from lower socioeconomic backgrounds (Robinson et al., 2021). Thus although set-point theory can explain some of the biological factors in weight maintenance, it does not account for socio-economic, behavioural or environmental influences.

The model favoured by psychologists and nutritionists is the settling point theory, which proposes a more passive feedback mechanism between the body's fat stores and energy expenditure, as it attempts to explains the social and environmental mechanisms behind energy balance. The settling point can be likened to a lake, where the body's energy stores are like the water, with an inflow (food energy) and outflow (energy expenditure). If inputs rise (higher food intake), the water levels rise until the banks are breached and output increases until equilibrium is restored i.e. water levels (fat stores) reduce but there is no specific set-point nor feedback system (Speakman et al., 2011). This is called a "settling point" because the system settles at a point defined by the unregulated parameter, in this case energy intake which is independent of bodyweight, meaning that as weight increases, it doesn't affect energy intake. As intake increases and weight goes up, energy expenditure increases to a level matching energy intake, weight gain stops and settles at this point (Hall and Guo, 2017). This model partly explains rising obesity prevalence as a function of increased availability of energy-dense food and lower activity levels (the obesogenic environment).

However, neither model can account for the interplay of genetic and environmental factors that are undoubtedly responsible for individual bodyweight fluctuations in a common environment. More recently, the general intake model and dual intervention point models have been suggested as theories offering a more complete explanation of this complex interaction.

The general model of intake regulation combines aspects of both set-point and settling point theories and aims to account for environmental and psycho-social aspects of energy balance as well as physiological factors (de Castro and Plunkett, 2002). Influences are separated into uncompensated (mainly environmental) and compensated (physiological) factors, the latter having negative feedback loops with intake, meaning they are both affected by and affect intake. However, uncompensated influences affect but are not affected by intake. This model assumes food intake is a result of all the compensated and uncompensated factors, and does not assume there is any set-point for weight or fatness, instead any change in one of the factors will alter bodyweight level that is defended. So if all factors are stable, it might look as though a set-point was in operation, but if a factor changed (for example, physical activity decreased), a new weight would become the norm. This model also predicts that after weight loss, compensated (physiological) factors would increase intake levels until the previous weight is reached, which would partly explain the phenomenon of yo-yo dieting (Hall and Kahan, 2018).

Finally the dual intervention point model posits that rather than a set point for bodyweight, there are upper and lower boundaries at which physiological mechanisms of weight regulation become active (Müller et al., 2018; Speakman et al., 2011). What differentiates this from a wider set point, is that there is no defined target weight and the two intervention points operate independently, meaning the range between the two points could be wide and vary between people, explaining the variability in individual responses to the environment. It is theorised that the upper intervention point is regulated by the risk of predation and the lower point by the risk of starving (Speakman, 2007, 2008). That is, the risk of predation diminished with evolutionary developments such as the use of fire and tools and the genes coding for the upper intervention boundary "drifted" over time, and some people have lost strong internal control over weight increase. In summary, this model suggests genes control the size of the difference between the two boundaries but environmental factors effect energy balance in the space between (Speakman et al., 2011).

These biological systems are clearly unconscious but are supplemented by cognitive, emotional and executive higher brain functions, which drive conscious choice and action, such as eating in response to stress or to alleviate boredom. Therefore although biological factors set the scene for an individual's weight maintenance, or otherwise, factors such as the presence of a bakery on someone's route to work or multiple adverts for takeaway pizza on Saturday night have an influence on behaviour which has a direct impact on weight. The external influences on appetite and eating behaviour, including what has been termed the obesogenic environment, are explored in the following section.

2.2.1.3 The obesogenic environment

Although humans have innate mechanisms for energy balance as noted in the previous sections, we are living in what has been termed an obesogenic environment, defined as "the sum of influences that the surroundings, opportunities or conditions of life have on promoting obesity in individuals or populations" (Swinburn, Egger, & Raza, 1999).

From an evolutionary perspective, this external environment is an emerging phenomenon affecting both sides of the energy balance equation by providing abundant cheap, hyper-palatable food which leads to "passive-overconsumption" (Beaulieu, 2017), while changing the built environment to prevent rather than encourage physical activity, which can and often does override an individual's internal system of energy homeostasis (Anderson and Butcher, 2006; Berthoud, Morrison, & Munzberg, 2020).

Changing social environments have also influenced obesity prevalence. For example, growth in the number of families where both parents work, single-parent families with a working parent or parents doing shift work may mean greater reliance on convenience foods and take-aways (Wu, 2018). The recent UK Millennium Cohort Study, which followed children from 0 to 7 years, found that there was an increased risk of overweight when either no-one in the house hold worked or both parents worked full-time, but not when only one parent was employed (Hope, Pearce, Whitehead, & Law, 2015).

Another aspect of our changing environment is the rise of screen use in children and adolescents, which displaces physical activity and decreases energy requirement from food but can increase "informal" eating occasions, such as eating snacks in front of the TV (Guo et al., 2020; Parkes, Green, & Pearce, 2020; Robinson et al., 2017). Screens also potentially increase children's exposure to marketing from food manufacturers, which can promote the desire to eat the advertised product, which is likely to be a processed food high in fat, sugar or salt (Norman et al., 2020).

One factor that should be discussed is social inequality: children living in poverty or areas of social deprivation have a greater prevalence of overweight and obesity (Chung et al., 2016; El-Sayed, Scarborough, & Galea, 2012; Kinra, Nelder, & Lewendon, 2000; McLaren, 2007; Yusuf et al., 2020). There are many reasons behind the association between deprivation and weight including obvious factors such as having less money to spend on food, which may necessitate buying cheap, filling, energy dense food, which is often high in refined carbohydrates, fat, sugar and salt. Thus those living in deprived areas may have a lower diet quality, with a higher intake of processed meat, refined carbohydrates and fast food (Burgoine, Sarkar, Webster, & Monsivais, 2018).

2.3 The issue of poor diet quality in children

The influences on overweight and obesity in children are varied and rightly attract significant media and research attention but also of concern is the quality of the diet they are eating. The two of course are inextricably linked: we not only have an obesity crisis but according to the WHO a "double burden of malnutrition", in which undernutrition and obesity coexist. They may exist either within an individual, for example an overweight child with iron deficiency anaemia, or within a community or region with high levels of undernutrition and obesity (WHO, 2017). Thus, when assessing the impact of nutrition in childhood, dietary quality needs to be addressed alongside weight, since the nutrient density of the diet can affect both risk for obesity and wider health concerns such as cardiovascular disease, diabetes and mental health conditions (Linardakis, Bertsias, Sarri, Papadaki, & Kafatos, 2008; Monteiro, Cannon, Lawrence, Costa Louzada, & Pereira Machado, 2019).

When diet quality and obesity was examined in a large prospective study of 120,877 US adults over a 20 year period, the strongest associations between weight gain and dietary choices were found with consumption of crisps, sugar-sweetened beverages, red meat and processed meat, while inverse associations were seen for vegetables, fruits, whole grains, nuts and yoghurt, with increased consumption resulting in less weight gain. All weight changes were adjusted for age, baseline body-mass index, sleep, changes in smoking status, physical activity, television watching, and alcohol use, and average weight gain over 20 years was 16.8lbs (7.6kg). The authors suggested that dietary quality influenced dietary quantity, possibly due to less energy-dense foods such fruit and vegetables displacing more energy dense choices, higher fibre intake increasing satiety and the influence of dairy produce on the microbiome of individuals (Mozaffarian, Hao, Rimm, Willett, & Hu, 2011).

Diet quality has no formal definition, mainly because a "healthy" diet varies with the needs of the individual, the foods available and cultural dietary customs, but attempts have been made to measure diet quality with the creation of indices that allow researchers to quantify intake patterns in a sample population's diet and then associate the results with health markers such as cardiovascular disease (Alkerwi, 2014). For example, investigators have developed tools such as the Healthy Eating Index (HEI), (Guenther et al., 2013), the Diet Quality Index-International (DQI-I) (Kim, Haines, Siega-Riz, & Popkin, 2003), and the Alternative Healthy Eating Index (AHEI), which focuses on foods and nutrients predictive of chronic disease risk or protection (Chiuve et al., 2012).

However, diet quality remains a poorly defined, heterogenous concept. The tools above are designed to measure portions of foods in relation to government recommendations or patterns of eating and there are few instruments specifically designed to be used in young children, although modified forms of the HEI and DQI have been used for infants as young as 6 months (Au et al., 2018; Feskanich, Rockett, & Colditz, 2004; Hamner and Moore, 2019; Luecking, Mazzucca, Vaughn, & Ward, 2020).

2.3.1 The scale of the problem in the UK: what are children eating?

In the UK regular attempts are made to measure what the population is eating. One such survey is the National Diet and Nutrition Survey (NDNS) which has taken place every two years from 1992 onwards and has documented the consumption of several key foods in the population. The latest available data is from 2016-17, and covers adults and children over 18 months old. The NDNS measures calories from food, saturated fat consumption, free sugars (from juice and those added to foods, not from whole fruits or milk), the percentage of each group achieving five portions of fruit and vegetables a day, red and processed meat consumption and sugar-sweetened beverage intake.

From the latest figures available (2016-17):

Free sugar intake:

- 13% of 1.5-3 year olds met the Scientific Advisory Committee on Nutrition (SACN) recommendation to keep intake at no more than 5% of energy (mean intake 32.6g/day).

- 3% of boys and 1% of girls aged 4-10 met the recommended 5% mean intake of 54.5g for boys and 49.9g for girls.

These figures have decreased by 2.7% for children aged 1.5-3 years and 2.4% for 4-10 year olds since the survey started in 2008-9, which suggests sugar consumption may be reducing.

The main source of free sugars in children under 11 in 2016/17 was cereals and cereal products (such as bars), followed by soft drinks/fruit juice and sweets/confectionery.

Fibre intake:

- 10% of 1.5-3 year olds met the recommendation of 10g/day for fibre.

- 11% of boys and 9% girls met the 15g recommendation for 4-10 year olds.

The main sources of fibre across all ages were cereals/cereal products, potatoes, vegetables and fruit.

Saturated fat intake:

- Maximum intake of 11% of energy from saturated fat was exceeded by all age groups.

Fruit and vegetable portions were only measured in 11-18 year olds; while total weight was measured in toddlers:

- Children aged 1.5-3 years consumed 170g of fruit and vegetables.

As well as the UK NDNS, the Health Survey for England (HSE) examines various metrics of health including weight, activity, alcohol and tobacco use, as well as fruit and vegetable consumption. This survey also includes babies and children in some metrics and last took place in 2018, finding that 18% of children aged 5-15 years ate the recommended 5 a day portions of fruit and vegetables (NHS, 2019a).

2.3.2 The impact of poor diet quality

Clearly, most children are not meeting healthy eating guidelines and this is an undesirable situation given the links between poor diet quality and both obesity and social issues affecting both the individual and community (Florence, Asbridge, & Veugelers, 2008; Jackson, 2016).

With regard to the links between diet quality and weight, there is growing evidence that poor diet quality is linked with a higher risk of overweight and obesity, both in adults and children. For example, the Canadian QUALITY study, which examined the relationship between diet quality as measured by the DQI and body fat in 8-10 year olds, found that a higher diet quality was associated with lower body fat percentage and central adiposity (Setayeshgar et al., 2017), while obese preschool children in the US LAUNCH intervention study, which compared BMI and diet quality before and after a six-month family behaviour change course, found those in the study group had a reduced BMI and higher diet quality than those receiving standard care or motivational interviewing. In particular, the children in the behaviour change group consumed more fruit, fewer sugary drinks and fewer sweet or salty snacks (Robson et al., 2019).

Poor diet quality in expectant mothers has also been linked with overweight and obesity in infants. Low scores on the HEI in pregnant women have been associated with large for gestational age babies, independent of maternal obesity in one US study (Zhu et al., 2018), while a Greek study of children 8-14 using the HEI found a link between poor diet quality scores and metabolic syndrome, including overweight (Linardakis et al., 2008).

The link between poor diet quality and obesity has also been observed in adults and is pertinent due to the tracking of obesity from childhood into adulthood. For instance, a study of the US NHANES data 2001-2008 found that obese adults had lower micronutrient intakes than those of normal weight (Agarwal, 2015), while an analysis of the

2007-2014 NHANES data found that calcium, magnesium, zinc and potassium intakes were negatively correlated with BMI but sodium and phosphorous were positively correlated. Calcium intake can be related to dairy intake while the authors of this study suggested that potassium intake was indicative of fruit and vegetable consumption, positing that high potassium intake might be protective against obesity (Jiang et al., 2020). The reverse was the case for sodium intake, which was higher in obese subjects, possibly reflecting a higher intake of processed and snack foods.

In terms of social and behavioural issues, there is some evidence linking poor diet in pre-schoolers to anti-social behaviour in school (Jackson, 2016), and it has long been known that undernutrition in early childhood has consequences for health and well-being that extends into adulthood, including premature death, blindness, growth stunting, poor pregnancy outcomes and cognitive impairment (Dewey and Begum, 2011; Howson, Kennedy, & Horwitz, 1998; Martorell, 1999). Low diet quality in children has also been linked to poorer academic performance and behaviour in childhood (Cohen, Gorski, Gruber, Kurdziel, & Rimm, 2016; Florence et al., 2008; Jackson, 2016) and clearly this has long term consequences due to its influence on attainment and the child's ability to reach their potential in life (Nyaradi, Li, Hickling, Foster, & Oddy, 2013). Thus through its impact on academic achievement and consequent influence on working life, poor diet quality affects not only the individual child but also their family and the wider community. Conversely, if a child has a good quality diet with low reliance on ultra-processed foods, they may be more likely to reach their potential at school and therefore have more options in life.

2.3.3 Influences on poor diet quality in children

As outlined in the previous section, diet quality impacts on a child's health and life chances, but what are the factors that influence the quality of a child's diet? Clearly, socio-economic factors are key: a family in poverty will have fewer choices around diet than a family with a high income. Indeed, by whichever metric poor diet quality is measured, it has roots in common with overweight and obesity such as deprivation and lower socio-economic status (van der Velde et al., 2019; Yannakoulia et al., 2016). For instance, a Swedish study of 2160 children found a positive relationship between HEI score and diet cost, parental education and occupation, suggesting that diet quality increases with economic status (Ryden and Hagfors, 2011), while the pan-European HELENA study of 1768 adolescents found that the DQI was positively correlated with parental occupation and education (Beghin et al., 2014). Similarly to obesity, poor diet quality in children has been linked to lower educational attainment in parents (Desbouys, Méjean, De Henauw, & Castetbon, 2020).

Another factor linked to diet quality in some studies is parenting style. A caregiver's parenting style is the combination of strategies used to raise their children. The four classic styles of parenting were outlined by Diana Baumrind in the 1960s and are described as authoritative, authoritarian (disciplinarian), or permissive, either indulgent or uninvolved depending on how responsive and warm or demanding and controlling parents are (Darling and Steinberg, 1993; Hubbs-Tait, Kennedy, Page, Topham, & Harrist, 2008).

These parenting dimensions (responsiveness vs demanding) derive from Baumrind's research in child development, which described their potential impact on child behaviour and interactions. Authoritative parenting is characterised by high levels of control and high warmth (or responsiveness), meaning parents are responsive and affectionate but also have high expectations and create boundaries for their children. This style of parenting is associated with children who are independent and have self-control. Authoritarian parenting is associated with high control, emotional coldness, strict discipline and possible insensitivity to a child's emotional needs. Children raised this way can be motivated by external rather than internal controls. Lastly, permissive parents are low in control and either low (neglectful) or high (indulgent) in warmth. They have low expectations for their children's behaviour and set few boundaries, which can potentially lead to poor self-regulation and self-control (Baumrind, 1966).

Parenting styles are also associated with the diet parents feed their children. For example, one American study found that a permissive parenting and feeding style was associated with higher consumption of low nutrient dense foods, sugary drinks, fats and oil but also meat, beans and milk in 9 year old children (Hennessy, Hughes, Goldberg, Hyatt, & Economos, 2012). The authors suggested this was could be due to more child-led snacking as parents in this study were generally in low-income groups and expressed that they had to say no to requests for toys and clothes but could say yes to food-related asks, which demonstrates another way that SES and eating habits can interact.

Another study of school aged children in the USA, found a positive association between an authoritative parenting style and mealtime structural practices and parent modelling of healthy foods. Permissive and authoritarian parenting styles were negatively associated with these behaviours, and having mealtime structures and food rules were associated with a higher HEI score (Lopez et al., 2018). Mealtime structure, food rules and parent modelling found in authoritative parenting, were all positively associated with calorie-adjusted fruit and vegetable intake, suggesting that attitudes to parenting and mealtimes are factors in the diet quality of children.

An interesting recent study of 171 low-income parent-child dyads (9-15 years) in the US, found permissive parenting styles were significantly associated with lower diet quality as measured by the HEI, while the highest diet quality was found in children of parents who displayed both authoritative and authoritarian behaviours. The authors suggested that using the best aspects of the different styles could achieve the most desirable results in terms of healthy food intakes, such as strictly directing a child's food choices but providing reasons behind the decisions and a warm, loving environment (Burke, Jones, Frongillo, Blake, & Fram, 2019).

2.4 The role of food fussiness

It is not solely what children eat but also how and why they eat, that determines whether they develop a positive relationship with food. As well as our tastes and preferences, we form our behaviours and habits around food, whether positive or negative, in our earliest years. One element that affects what foods children will consume and in what quantity is food neophobia and fussy eating. Parents can offer a whole range of nutrient dense foods to their children but if they are unwilling to consume it, they will not benefit.

Food neophobia is the reluctance to eat, or avoidance of, new foods (Dovey, Staples, Gibson, & Halford, 2008; Pliner, 1994) and is one aspect of picky or fussy eating. However, there is no standard definition of food fussiness or pickiness in the literature and this has hampered research in the area, particularly when conducting systematic reviews, which rely on comparison of studies with similar methodologies. However, one review of the various definitions and prevalence of these eating behaviours defined picky (as well as fussy, faddy or choosy) eating as an unwillingness to eat familiar foods or to try new foods, as well as strong food preferences (Taylor, Wernimont, Northstone, & Emmett, 2015).

There is evidence that children who are picky or fussy eaters, reject foods considered healthy such as fruit and vegetables, but accept palatable, energy dense foods (Cole, An, Lee, & Donovan, 2017; Cooke, Carnell, & Wardle, 2006; Lafraire, Rioux, Giboreau, & Picard, 2016; Perry et al., 2015; Russell and Worsley, 2008). This pattern was also reflected in a recent study from the USA examining data from the two most recent NHANES surveys (2013 and 2016), which found that consumption of highly palatable Ultra Processed Foods (UPFs) was correlated with poor diet quality in both children and adults, suggesting that UPFs displace nutrient-dense foods in the diet (Liu et al., 2020).

Looking at the prevalence of fussy eating in children, findings have been mixed, partly because, as mentioned above, there is no clear definition of what constitutes picky or fussy eating (Taylor et al., 2015). Studies use the terms picky, fussy, choosy or faddy eating interchangeably, and tools developed to assess fussiness range from a single item question such as "Is your child a picky eater?" to more complex multi-item sub-scales in larger questionnaires like the Child Eating Behaviour Questionnaire (Wardle, Guthrie, et al., 2001). Yet fussiness remains hard to define and can range from neophobia often seen in toddlers to ARFID (Avoidant/Restrictive Food Intake Disorder), a severe form of fussiness which impacts on normal development (Hay et al., 2017)

However, despite the lack of a clear definition, work in this area has progressed. A Canadian study among 2.5 to 4.5 year olds, found 30% were considered fussy (Dubois, Farmer, Girard, Peterson, & Tatone-Tokuda, 2007), while a study from the USA found 50% of 2 year olds were reported as fussy by their parents (Carruth, Ziegler, Gordon, & Barr, 2004). Research in older children, reported that 13-22% of children from 2-11 years were picky eaters (Mascola, Bryson, & Agras, 2010), while a longitudinal study of over 4000 1.5 to 6 year olds found that 46% of children had been considered fussy by maternal report at one point during the study. However two thirds of those who had been considered fussy earlier in the study had stopped by the age of 6, which the authors suggested demonstrated that fussiness was a normal, transient part of childhood (Cardona Cano et al., 2015). In a review of studies cited above, Taylor et al (2015) found prevalence varied widely, from 7.3 to 59% depending on the age of the children involved and how pickiness was defined.

An interesting longitudinal study looking at consistency of food variety over the years from initial survey at 2-3 years of age to multiple follow-ups at 4-22 years found that "food variety seeking" was stable over time, so those who chose the widest variety of foods as toddlers maintained this variety into young adulthood (Nicklaus et al., 2005). The authors also found that neophobia was a somewhat stable trait but there was a decrease seen between follow-up at 4-7 years and 8-12 and then again between 8-12 and 13-22 years. The reasons that pickiness appears to be a trait will be discussed in section on genetics below.

2.4.1 The impact of neophobia and fussiness in toddlers/children

While it may be normal and may not extend into adulthood, fussiness and food neophobia can be distressing for parents, if not their children, and cause issues within the family (Goh and Jacob, 2012; Mascola et al., 2010; Wright, Parkinson, Shipton, & Drewett, 2007). For example, Goh et al (2012) found that in a study of 407 Singaporean caregivers, picky eating was significantly associated with caregiver stress when feeding and having a negative impact on family life and this stress increased with the number of picky eating behaviours experienced.

There is also some evidence that fussiness and neophobia impact on weight trajectories. Several studies have found a higher risk of overweight (Faith, Heo, Keller, & Pietrobelli, 2013; Finistrella et al., 2012), while others have found an association between picky eating and underweight due to reduced energy consumption and lack of variety (Dubois, Farmer, Girard, Peterson, et al., 2007; Ekstein, Laniado, & Glick, 2009).

However a 2016 meta-analysis of 41 studies examining any links between fussy eating, food neophobia or picky eating and weight status found no association in 17 cases, 2 found a positive relationship with picky/fussy eating and overweight, 5 had a negative association with overweight or obesity, 6 found a positive link with underweight and 11 found a decreased association with BMI but didn't say if this was underweight or a decreased risk of overweight (Brown, Vander Schaaf, Cohen, Irby, & Skelton, 2016). In their analysis, the authors highlighted the inconsistencies in definitions of picky or fussy eating, which hinder comparisons of study results. However, although on balance from these results it would seem that there is a higher likelihood that pickiness would be associated with a lower weight trajectory, the authors concluded that the results showed no clear association.

As has been discussed previously, fussiness has also been linked to lower fruit and vegetable consumption in childhood, which for some individuals has been found to track into adolescence and adulthood (Berger, Hohman, Marini, Savage, & Birch, 2016; Dubois, Farmer, Girard, & Peterson, 2007; Nicklaus, Boggio, Chabanet, & Issanchou, 2004). For example, a prospective study by Nicklaus et al (2004) of 341 children and adolescents examined the self-directed food choices of toddlers aged 2-3 years in a French nursery, and were followed up when they were either 4-7, 8-12, 13-16 or 17-22 years of age. The authors found that individual food preferences were highly stable throughout childhood and adolescence, especially for strong chesses, vegetables and meats. Berger et al (2016) also followed a cohort into adolescence (n = 181 girls) and found those classed as "persistently picky" aged 15 (18% of the study group) ate significantly fewer vegetables than those who were non-picky, although neither group met the recommended intake for fruit and vegetables.

This highlights the importance of introducing a wide variety of healthy foods early in a child's life: without experiencing the taste of foods, children won't be able to form flavour preferences and given the worry it can cause parents when their children refuse food and the frequency with which fussiness occurs, it is worth addressing its potential causes and consequences, and whether food neophobia can be improved.

2.4.2 Influences on the development of fussy eating.

Even before an infant has been exposed to their family environment or experienced their first taste of food, there is strong evidence that our genes have a key role in our personal taste preferences. However, our early interactions with food and family dynamics are also key influences in our preferences and create the experiences that shape later behaviour.

2.4.2.1 Genetic and biological causes

With regard to a child's aversions or attitudes to different foods, there are a number of studies that show food fussiness, neophobia and poor diet quality may have genetic and biological causes. From an anthropological and evolutionary perspective, fussiness and avoidance of new tastes during the early months and years of eating solid foods alongside a preference for high fat and sugary foods may be adaptive. Children across cultural groups tend to prefer foods high in fat and sugar, which would be beneficial for survival, along with disliking vegetables, which tend to be sour or bitter, flavours that can indicate toxins or other harmful components (Bellisle, Rolland-Cachera, the Kellogg Scientific Advisory Committee, & Nutrition', 2000; Cooke and Wardle, 2005; Skinner, Carruth, Bounds, & Ziegler, 2002). Indeed, a preference for sweetness has been documented in newborns, as has a dislike of bitter or sour tastes, indicating an innate biological inclination for flavours (Beauchamp and Moran, 1982; Desor, Maller, & Turner, 1973; Desor, 1975).

Evidence for a genetic disposition in food preferences is mixed. For example, one study exploring taste preferences in identical and non-identical twins found high heritability for preferences around protein rich foods, but only moderate heritability for fruits, vegetables and dessert foods (Breen, Plomin, & Wardle, 2006). While another twin study suggested that like or dislike for fruits and vegetables and food fussiness are heritable (Fildes, van Jaarsveld, Cooke, Wardle, & Llewellyn, 2016). This particular study used data from the GEMINI cohort of twins born in 2007. At 3 years of age the children's parents were asked to complete a fruit and vegetable preference questionnaire and the "food fussiness" component of the Child Eating Behaviour Questionnaire. The authors compared the findings with results of genetic modelling to estimate genetic influences of underlying fussiness and preferences for fruit and vegetables and found in this sample that fussiness had a heritability of 78%, while there were significant negative correlations between fussiness and preference for fruit (-0.43) and vegetables (-0.65), with fussier children tending to dislike fruit and vegetables more than less fussy children.

Other twin studies focusing on neophobia (unwillingness to try or rejection of new foods) in children have found a high heritability of between 72% in a study of 4-7 year olds and 78% in 8-11 year olds (Cooke, Haworth, & Wardle, 2007; Faith et al., 2013). Interestingly Faith et al (2013) also found a link between high neophobia and higher BMI in parent-child pairs, which was contrary to some previous work. The authors posited that this may be due to neophobic children not trying vegetables and fruits and relying on familiar energy-dense foods. However, the findings of studies examining pickiness or neophobia and weight are mixed.

There is also evidence of genetic involvement in how individuals perceive certain tastes. Different individuals can perceive the same food to have a different taste, and like or dislike it accordingly. For example, bitter-tasting sulphur compounds such as 6-n-propylthiouracil (PROP) found in many vegetables are perceived by 30% of people as mildly or not at all bitter whilst 70% find them moderately or very bitter. Within this group, some people are "supertasters" who find these bitter compounds extremely strong and often unpalatable (Bartoshuk, Duffy, & Miller, 1994). Clearly, if a child finds a food unpalatable, they will be unlikely to eat it. However, results from studies are mixed with regard to PROP tasting and vegetable intake in children.

In a study of 525 Irish children aged 7-13 years who were assessed for fruit and vegetable preference and PROP tasting ability (non-tasters, medium tasters and super tasters), found no significant association between food preference and PROP sensitivity, having genes linked with super-tasting or number of taste buds. In fact, the only links to preference were found for socio-economic status (SES) and gender, with children from schools in lower SES areas liking vegetables more than those from higher SES areas; non-tasting boys liking cauliflower more than other tasting groups and non-tasting girls liking broccoli less than the other tasting groups (Feeney, O'Brien, Scannell, Markey, & Gibney, 2014).

However, other work has demonstrated an association between heightened PROP tasting and dislike of vegetables among younger children. One Italian study of adults and children (aged 3+) found that there was a higher frequency of supertasters among children (30.2%) compared to adults (16.3%), and that being a supertaster was associated (although not significantly) with eating fewer vegetables, and supertaster children ate significantly fewer vegetables than supertaster adults (Negri et al., 2012). A recent study with Danish teens found that having a high bitter taste threshold (being less sensitive to bitterness) was positively associated with familiarity and liking of vegetables (Hald, Hald, Stankovic, Niklassen, & Ovesen, 2020).

In addition, food fussiness has been linked with certain heritable personality traits such as anxiety (Farrow and Coulthard, 2012), while children who are more accepting of food are higher in "sensation seeking" (Galloway, Lee, & Birch, 2003). Therefore it is possible that fussiness may also be seen within families due to inherited anxiety and other personality traits (Galloway et al., 2003; Knaapila et al., 2007). However any heritability of fussiness or anxiety may be hard to disentangle from behaviours modelled by caregivers, as there is evidence that food fussiness in children may be linked to anxiety and depression in a parent (de Barse et al., 2016). There is also evidence that a child's perceived personality can influence maternal feeding attitudes, with the NOURISH study from Australia demonstrating that mothers who perceived their babies to be more difficult, had reduced awareness of infant cues, were more likely to use food to calm and had more concerns about overweight and underweight. Maternal depression was also reflected in these behaviours (McMeekin et al., 2013)

Although fussiness may have a genetic component and humans have an innate preference for certain flavours, we also learn through experience and are adaptable as a species. There are other reasons why we learn to accept and enjoy certain foods. These include all our learned experiences with a food and wider factors surrounding that exposure, for example was it a positive or negative experience, such as choking or sickness after consuming the food, which can cause long-standing aversion (Birch, McPhee, Steinberg, & Sullivan, 1990; Yeomans, 2010). Factors that influence our acceptance of a food including whether we are initially offered a food and the quality of that presentation, alongside factors surrounding our exposure to it, such as the way it is offered by a caregiver, our experience of eating it and associations with receiving the food can also affect out preferences for it. So what are these factors?

2.3.2.2 Exposure

The home environment is where a child learns to eat, and unsurprisingly, a child's diet is influenced primarily by that of their parents (Cooke et al., 2004; Wyse, 2011). Parents can also influence a child's diet with their attitudes and personality, via pressure, restriction or manipulation of the food and meal environment (Brown, Ogden, Vogele, & Gibson, 2008). An important influence on food acceptance is therefore whether a child has actually ever been offered that food.

Familiarity and repeated exposures are important factors in the acceptability of food, unsurprising given that a familiar food may be associated with safety e.g. a positive physical reaction after eating it (Aldridge, Dovey, & Halford, 2009; Birch and Anzman-Frasca, 2011). Many studies have found that experiencing a taste in early childhood and possibly even in utero or breast milk increases the likelihood of its acceptance later (Mennella, Daniels, & Reiter, 2017; Mennella, Jagnow, & Beauchamp, 2001; Skinner, Carruth, Bounds, Ziegler, & Reidy, 2002) and repeated exposure has been found to be a useful tool for increasing children's acceptance of vegetables and unfamiliar tastes (Cooke, 2007; Sullivan and Birch, 1994; Wardle et al., 2003).

Social facilitation or positive peer pressure has been suggested as another factor in food preference. If children see friends or siblings eating a food, they are more likely to try the food and eat more of it themselves and may be used unconsciously by parents who eat a mouthful of their infant's food and make exaggerated noises of enjoyment, to encourage their baby to eat (Salvy, Vartanian, Coelho, Jarrin, & Pliner, 2008). Parental modelling is another factor in children's consumption patterns, as they tend to imitate the behaviour of adults and older children in their environment, thus increasing preference through repeated exposure (Blissett, Bennett, Fogel, Harris, & Higgs, 2016; Holley, Haycraft, & Farrow, 2015).

Children who are severely food neophobic may be averse to certain foods for years. One longitudinal study of 70 mother/child dyads found that those who were most neophobic at 2-3 years of age, disliked or had tried the fewest foods at 8 years, and this consistency extended to positive preference – the number of foods liked at 8 years of age was most strongly predicted by the number of foods liked at 4 years (Skinner et al., 2002). Interestingly mothers' and children's food preferences were significantly related but mothers were less likely to offer foods to their children that they themselves disliked. However, it is unclear whether parents stopped offering new foods if their child displayed neophobia or whether not offering or being exposed to a variety of foods leads to neophobia. In this instance, the study design combined the answers to "never offered" with "never tasted", which made it impossible to uncouple whether a parent offered foods which were then not tasted by the child or simply did not offer a food. This difference is pertinent when looking at food fussiness and preference, since a child cannot form a preference for a taste they have never experienced (Birch and Marlin, 1982).

Certainly, parents may cease offering new foods and take the path of least resistance when it comes to feeding their child if what is offered is consistently rejected. There is evidence that children with a less easy personality are offered more obesogenic foods, perhaps in an effort to placate emotionally but it is unclear whether this also applies specifically to fussy children (Vollrath, Tonstad, Rothbart, & Hampson, 2011). There is however, evidence that fussy children tend to reject fruit, vegetables and protein foods over carbohydrates (Cooke, Wardle, & Gibson, 2003), which would suggest that they may eat more energy-dense foods as a result.

2.4.2.3 Parental child feeding style

Our experiences with food do not simply come from being exposed to it, but rather the wider experience of eating it. An aspect of the child's environment that may impact on later health are the parenting and feeding styles of a children's carers. Indeed, as parents are responsible for providing virtually all food and drink at this age, they play a pivotal role in shaping a child's own attitudes and behaviours around food, as alluded to above. A wide body of research has shown that parents do not simply offer children a range of foods when they are hungry. Instead they hold beliefs around what foods children should and should not eat, when they should eat and how much they should eat. These beliefs and feeding practices can have unintended consequences upon child eating behaviour and subsequent weight (Benton, 2004).

There are several theories seeking to describe and quantify the influence of a parent's feeding style on a child's eating behaviour and consequent weight. Some of the seminal work in this area was carried out by Dr Leann L Birch, who as well as pioneering research into exposure, food acceptance and childhood eating behaviours starting in the 1980s, developed the Child Feeding Questionnaire (CFQ) to measure the impact of parental attitudes on children's eating habits and resultant weight (Birch et al., 2001; Johnson and Birch, 1994).

The CFQ emerged from research by Birch which attempted to address the environmental factors in obesity influenced by parental behaviour and attitude by building on the existing knowledge that children could self-regulate their intake in the earliest years of eating a mixed diet (Birch and Fisher, 1998). Birch suggested that

For example, several studies have found that in children over 12 months of age, parental restriction of food, perhaps with the idea of reducing or controlling a child's weight, has been associated with increased consumption when given free access or when children become old enough to make their own choices (Birch, Fisher, & Davison, 2003; Faith and Kerns, 2005; Fisher and Birch, 1999b; Rollins, Loken, Savage, & Birch, 2014; Webber, Cooke, Hill, & Wardle, 2010). Is this due to a parent reacting to a child's increasing weight or perceived overweight, or is the increase in food-seeking behaviour (and subsequent weight gain) of the child a response to the restriction imposed by their caregiver?

Clearly, it is an innate human characteristic to want access to "forbidden fruit" (or chips and biscuits), even more so if access is rationed or restricted, which means when or if the child has access to foods otherwise restricted, their intake may increase even when not hungry, and this has indeed been evidenced (Fisher and Birch, 1999a; Rollins et al., 2014). Rollins (2014) replicated the work by Fisher and Birch (1999a) but also examined the personalities of the children who seemed most susceptible to restriction-overeat tendencies and found them to have lower inhibitory control and higher in approach (a temperament trait exemplified by greater levels of excitement or positive mood when anticipating enjoyable activities like eating). Thus children who are less inhibited and experience more anticipatory excitement are more likely to be negatively affected by restriction and consequently either pester their parents for the food being controlled or eat more when able to do so.

However, the response to restriction may not be as straightforward as once thought. Although the research cited above (Birch et al., 2003; Birch et al., 2001) suggests that restriction due to higher levels of parental control results in overweight, due to children choosing more of the restricted food when able and the negative impact on the child's relationship with food, it has been suggested that lack of parental control over food intake might negatively impact weight, if parents do not promote nutrient-dense foods or allow unfettered access to high-energy foods (Wardle, Sanderson, Guthrie, Rapoport, & Plomin, 2002). Similarly, other work has reported that higher parental control led to increased intake of healthy snack foods, which may *positively* impact weight (Brown and Ogden, 2004).

It is possible that the different results seen reflect the differing measures used, with Birch using the CFQ (Birch et al., 2001) and Wardle using the Parental Style Feeding Questionnaire (PFSQ) (Wardle et al., 2002). Alternatively, it may reflect that parental control is a more complex paradigm than previously reflected in existing tools. For example, as well as exerting control by encouraging healthy choices and limiting undesirable foods, parents may exert control by manipulating their child's environment, perhaps by not bringing cookies and crisps into the house or avoiding certain restaurants. This is termed "covert" control as the child remains unaware of the steps the parent is taking to control their food environment (Ogden, Reynolds, & Smith, 2006), as opposed to "overt" control measures, such as telling a child to take an apple rather than a cookie, making the child aware of the restriction.

Looking at potential differences between the consequences of overt and covert control, one study using a novel measure of restriction found that covert control was related to decreased unhealthy snacking, while overt control was related to increased healthy snacking (Ogden et al., 2006), suggesting that parents might find not bringing energy-dense snacks in to the home works better to change behaviour than simply telling children not to eat them.

Conversely, encouraging and modelling eating healthy snacks might increase consumption more than simply having a fruit bowl on the table.

A recent study from Australia looking at restrictive feeding practices and food preferences using a prospective study design, suggested that restrictive feeding (overt control) at age 4 was associated with a lower preference for fruit and vegetables and a higher preference for sweets at age 6, with the converse true for those children who had experienced covert control by their parents, with children having a higher preference for fruit and vegetables and a lower preference for sweets after two years (Boots, Tiggemann, & Corsini, 2019). Parent feeding style was not associated with BMI or preference for salty snacks.

The authors posited that the restrictive feeding measured by the CFQ is a form of coercive control, while covert restriction is a form of structure where access to unhealthy foods is limited and routines are created to manage the child's environment. This has a positive influence on a child's development of self-regulation and improves diet quality without the emotional upset which may be present when restriction is overt (Rollins, Savage, Fisher, & Birch, 2016; Savage, Rollins, Kugler, Birch, & Marini, 2017). The findings of these studies provide further underpinning for the theory that the reduced parental control intrinsic in baby-led weaning may be beneficial to children's long term eating habits.

At the other end of the spectrum, putting pressure on a child to eat, out of concern for the amount or type of food eaten, has been associated in many studies with fussiness and/or lower weight (Afonso et al., 2016; Faith, Scanlon, Birch, Francis, & Sherry, 2004; Galloway, Fiorito, Francis, & Birch, 2006; Jansen et al., 2017; Sutin and Terracciano, 2018; Ventura and Birch, 2008; Webber et al., 2010). Parents may choose to use these directive attempts to control their child's intake with the best of intentions but these feeding behaviours can disrupt a child's internal self-regulation cues, such sensations of fullness or hunger. Indeed, there are several studies that show fussy or picky eating can be associated with increased weight (Finistrella et al., 2012; Jiang et al., 2014), because disruption in self-regulation may lead to over as well as under eating and the foods deemed as acceptable by the child may be energy dense foods rather than fruit and vegetables, which may be rejected despite pressure or control exerted by parents (Gregory, Paxton, & Brozovic, 2011).

However, a recent systematic review looking at possible links between picky eating and neophobia and weight, found that in 17 of 41 eligible studies, there was no association with weight (Brown et al., 2016). Just two studies found a positive relationship with weight and the remaining 22 found either a positive relationship with underweight, negative relationship with overweight or obesity or a negative relationship with BMI or BMI z-score. The authors concluded that the heterogenous nature of definitions of picky eating and fussiness and the widespread use of parental identification of these behaviours led to an uncertain relationship with weight status. Clearly a widely agreed-upon definition of food fussiness would facilitate further research.

Controlling feeding practices such as pressure to eat are also associated with stress and conflict at mealtimes (Harris, Ria-Searle, Jansen, & Thorpe, 2018), but the anxiety around fussy or picky eating may be bidirectional in cause, with picky eating resulting in stress and anxiety for parents and the heightened emotional atmosphere (and subsequent pressure to eat) increasing the child's neophobia or fussiness as shown in a recent meta-analysis of qualitative studies looking at experiences of parents and their children at meal times (Wolstenholme, Kelly, Hennessy, & Heary, 2020).

As well as using specific feeding practices such as restriction or pressuring a child to eat, a caregiver's wider parenting style may influence the development of their child's attitudes to food. The relationship between different parenting styles and family eating environments has been explored in several studies. Using the Child Feeding Questionnaire (CFQ) and Parenting Styles and Dimensions Questionnaire (PSDQ), Hubbs-Tait et al (2008) found that parent feeding styles, such as restriction or monitoring, could be used to predict general parenting attitudes. Restriction, pressure to eat and monitoring significantly predicted an authoritarian parenting style, while responsibility, restriction, monitoring and modelling (low) predicted an authoritative style. Modelling (low) and restriction predicted a permissive parenting style, which was unexpected by the authors (Hubbs-Tait et al., 2008).

In turn, there is some evidence that parenting style may affect the degree and outcome of pickiness. It has been posited that a permissive parenting style may result in higher BMI by allowing a child to always reject healthier foods such as fruit and vegetables in favour of highly-palatable energy-dense foods (Vollmer and Mobley, 2013). One study of 1005 mothers of toddlers which examined the relationship between parenting style, feeding style and child eating behaviour, identified an "overprotective" parenting style that was associated with higher use of pressure and restriction (more commonly practiced by authoritarian parents) but also monitoring intake of less healthy foods and more healthy foods available in the home (van der Horst and Sleddens, 2017). This study found overprotective parents had children with lower food fussiness and a high enjoyment of eating, possibly because this parenting style is also warm and supportive, however there is limited evidence for strong associations between parenting style and child eating behaviours such as pickiness. Specific parental feeding styles such as restriction or pressure to eat seem to be more relevant and indeed, this study found an association between pressure to eat and food avoidance.

2.4.2.4 Socio-economic factors

Finally, socio-economic and cultural factors may also be related to levels of pickiness. In one US study of parents of pre-schoolers that compared attitudes between different income groups and cultures, parents from higher income groups were more likely to report picky eating. In addition, pressure to eat, concern about the child being underweight and using food to calm were reported more among Spanish-speaking Hispanic parents than English-speaking Hispanic parents, which the authors suggested was due to cultural differences which HCPs should be mindful of when giving advice (Evans et al., 2011).

2.5 Turning our attention to the first year of life:

Clearly childhood is a critical time for establishing lifelong food habits and preferences that will have a lasting impact on health. As outlined above, childhood obesity is a global issue with multiple interconnected causes, and research has focused on the biological, social and behavioural factors in its development, as a first step in finding solutions. Many factors have been identified in influencing the eating behaviours of preschool and older children but more recently attention has turned to infancy and the feeding environment of the child in their first year or two of life, and how this may influence weight and eating behaviours on a longer-term level.

Pregnancy and the first year of life is a period of rapid change and development where infants will triple their body weight and go from being solely dependent on their mother whilst in the womb to eating a milk-based diet to family foods at the end of this period. It is also unique in that infant development and self-feeding skills change immensely in this period. Infant vulnerability means that parents are heavily involved in feeding and food choices, and decisions made during this time may have lasting consequences. However although evidence is building for the impact of this time on later obesity, relatively little research has explored how experiences during the first year of life may impact upon child fussiness and diet quality.

2.5.1 Dietary recommendations for infants under one year of age

Although the UK government gives parents guidance on what to feed their infant in terms of milk feeding and introduction of solids, there are few recommendation on what infants under one year of age should be consuming in the UK with regard to amounts of specific foods (SACN, 2018). There are however recommendations for energy intake and certain nutrients of concern (SACN, 2018) and guidance on which foods are safe and appropriate weaning foods, as well as those to be avoided, such as honey, on the NHS Start4Life webpage (PHE, 2020).

Since 2001, the WHO has recommended that complementary foods be introduced at around six months, when the growing child has energy and nutrient requirements that cannot be met by breast milk alone (WHO, 2001, 2003). This becomes particularly important after 9 months of age when there may be an increased risk of iron-deficiency unless iron-rich foods are included in the child's diet (Agostoni et al., 2008). In the UK, official guidelines on weaning are given by Public Health England via the NHS Start4Life website. Parents are advised to introduce solids to their babies at "around 6 months" of age. The site suggests feeding pureed, mashed or sticks of one type of vegetable, fruit or baby rice as first foods. The site also recommends carefully introducing potential allergens and avoiding sugar and salt in infant foods, as well as emphasising feeding from different food groups and the importance of breast or formula milk for the first year (PHE, 2020).

The early weeks of starting solid foods should be about introducing tastes, with an increase in calories from around 7 months. From then on the Scientific Advisory Committee on Nutrition recommends approximately 650 to 700 kcal per day for babies 7-9 months and 715-765 kcal for babies 10-12 months. SACN also make recommendations for several key nutrients: vitamin A, D an iron. Iron intake of 2.3-4.3mg is recommended for infants of 4-6 months, while 4.2-7.8mg is recommended from 7-12 months. For vitamin D, a "safe intake" of 8.5-10mcg for infants to age 4 years is used as there is insufficient data regarding deficiency in this population, while for vitamin A an intake of 150-350mg is recommended for all infants aged 4-12 months.

2.5.2 What are infants actually eating during the weaning process and when?

Guidelines are clear but what are babies actually eating and when are they being introduced to solid foods? As outlined previously, much of the recent, large-scale research by the UK government focuses on children 18 months and over (NHS, 2019b). For infants in the first year of life, the UK Infant Feeding Survey was carried out every 5 years from 1975, however the 2015 survey was cancelled, with the last year of data being collected in 2010 (NHS, 2012). This means findings may well be outdated, especially if any improvements have been seen over the last decade.

The last survey in 2010 included over 10,000 mothers and asked questions about breast feeding and complementary feeding when their infants were 4-10 weeks, 4-6 months and 8-10 months old. The results showed a trend to later introduction of solids, more in line with government recommendations of "around 6 months": in 2005, 51% of mothers had introduced solids by four months, but by 2010 this had fallen to 30%. However, while there was an improvement, 75% of mothers had still introduced solids by the time their baby was five months old. This trend towards later introduction was less apparent in mothers from lower socio-economic groups, where 57% of mothers aged under 20 and 38% of mothers in manual work or had never worked had introduced solids by 4 months (McAndrew et al., 2012). When examining how ethnicity affected timing of introduction to solids, respondents of Black Asian and Minority Ethnic (BAME) origin introduced foods later than White respondents. 77% of White mothers had introduced solids by 5 months, compared with 66% of BAME mothers, with Asian and Chinese mothers being the least likely to introduce solids by 4 months.

Key highlights of infant diet included:

- Baby rice was by far the most frequent first food used (57%), while just 12% gave a commercial puree, 11% used home-made food and 10% offered rusks.

- With regard to the consistency of the food, 94% gave mashed or pureed food and only 4% gave finger food. However, by 8-10 months of age, 68% of mothers had offered finger foods to their babies.

- At 4-6 months, the most common foods given the previous day were fruit or vegetables (46%), commercial infant foods (38%), baby rice (31%) and home-made food (28%), emphasising a reliance on commercial baby products.

- At 8-10 months, 77% of babies had had fruit or vegetables the previous day, but home-made food was much more likely to be given at 8-10 month than at 4-6 months with 70% offering home-prepared foods, and only 44% using commercial infant foods.

- In terms of the types of foods given, 81% of babies were eating fruit, 80% were eating vegetables and breakfast cereals and 68% were having dairy products each day. Most babies were also eating potatoes, chicken, rice, pasta and bread each week. Other protein foods like beef, fish, lamb and pork were eaten less frequently. Foods that were often avoided completely included eggs, potato products (e.g. chips), vegetable proteins (e.g. tofu) and nuts.

- In terms of added salt, 90% completely avoided salt in their babies diets, while 38% avoided sugar and 19% avoided honey, as per government recommendations. This provides reassurance that health promotion messages are reaching their target.

There were significant variations in diet offered by maternal demographic background. Mothers in managerial/professional roles were more likely than mothers who had never worked to give vegetables, fruit, other fresh foods, breakfast cereal, dairy, bread, rice and pasta 3 times a week, and were less likely to offer ready-made foods, sweets, chocolates and biscuits, eggs and meat-substitutes (Quorn, soya mince and tofu). Giving healthier foods was linked by the study authors to higher income levels.

In terms of ethnic background and foods offered, BAME mothers were less likely to give dairy, bread, potatoes and spreads (e.g. butter) but more likely to offer meat substitutes. Asian mothers were the most likely to offer beans and pulses (33% compared to 15% of "all mothers") and sweets and chocolates (27% vs 21%), while Black mothers were most likely to give their children chicken (48% compared to 37% of all mothers), beef (22% vs 15%) and fish (28% vs 16%). Chinese mothers were most likely to offer pasta or rice (61%

vs 47% of all mothers) and eggs (22% vs 7%) but less likely to give breakfast cereal and ready-made foods than other mothers (McAndrew et al., 2012).

The US based Feeding Infants and Toddlers study is a cross-sectional survey of feeding practices and consumption patterns which has occurred in 2002, 2008 and 2016. The 2008 study found that compared to 2002, babies were being introduced to solids later, fewer infants aged 9-12 months consumed iron-fortified cereal and fruit and vegetable intake was lower than recommended. There was also a significant reduction in the number of infants who were not consuming any sweets, desserts, salty snacks and sweetened drinks (Siega-Riz et al., 2010). Data from the 2016 survey has shown an increase in breast milk consumption, and a decrease in sweetened drinks, 100% juice and sweets. However there was also a decrease in the percentage of infants consuming baby cereal, static or decreasing whole grain consumption and unchanged consumption of vegetables. Overall vegetable consumption is low at just 75g per day for any vegetable (including potatoes) at 6-12 months, dropping to 64g at 12-24 months. Without potatoes, these figures dropped to 68g and 45g respectively (Duffy et al., 2019).

2.5.3 Micronutrient consumption

Turning to individual nutrients, both iron and vitamin D have been targeted as nutrients of concern in UK nutrition surveys. Iron is a key nutrient for infants and toddlers, required for cognitive and motor development. The need for an external source of iron increases as infants move into the second six months of life as iron stored acquired maternally during gestation and birth are depleted (SACN, 2010). If sufficient iron from milk or complementary foods are not consumed or absorbed, the child may develop iron deficiency anaemia (defined as haemoglobin of <110g/L), which may lead to developmental issues if not resolved (SACN, 2010).

There is no national screening programme for iron-deficiency anaemia in the UK at present and levels of iron-deficency in infants and toddlers are unclear. One UK study from 2004, measured infants haemoglobin at 4, 12 and 24 months, finding that 34%, 23% and 13% of infants in these age groups had Hb concentrations lower than the WHO threshold for anaemia of 110g/L (Taylor, Redworth, & Morgan, 2004), which suggests that infants may not be consuming enough iron-rich foods, while a review of evidence by the Scientific Advisory Committee on Nutrition (formerly COMA) in 2010 suggested the prevalence of iron-deficiency anaemia in toddlers of 1.5 to 2.5 years to be between 5-6% (SACN, 2010). However, there is some evidence that the rates are higher in toddlers from certain ethnic groups of south Asian origin (Lawson, Thomas, & Hardiman, 1998).

In terms of intake, the latest UK National Diet and Nutrition Survey (NDNS) with data available, found the proportion of children aged 1.5–3 years with an iron intake under the lower RNI (the lowest 2.5% of the population) had increased to 10% in 2014-16 from the previous report of 6% between 2010-2012 (FSA, 2018), which suggests a decrease in intake in parts of the community with the lowest existing intake. Although IDA in the UK is not common, it is concerning given the increase in iron requirements seen in the early years of life and the link between IDA and developmental issues (Beard, 2008; Lozoff et al., 2006; Metallinos-Katsaras et al., 2004; Wachs, Pollitt, Cueto, Jacoby, & Creed-Kanashiro, 2005).

Vitamin D is another nutrient of concern in the UK. The SACN report on vitamin D in 2016 reviewed data from several National Diet and Nutrition Surveys (NDNS), the UK Diet and Nutrition Survey of Infants and Young Children (DNSIYC) in 2011 and the Health Survey for England (HSE) in 2005 and 2010 among others, to assess intake and potential deficiency in the population (SACN, 2016). This report found for formula-fed infants, mean daily intakes of vitamin D were 9.8µg/392IU at 4-6m, 8.7µg/348IU at 7-9m, 7.5µg/300IU at 10-11m and 3.5µg/140IU at 12-18m, with a recommended intake of 8.5-10mcg currently. For breastfed infants (excluding breast milk, as the amount of vitamin D in breast milk was variable) mean daily intakes were 3µg/120IU at 4-6m, 3.2µg/128IU at 7-9m, 2.7µg/108IU and 10-11m and 1.8µg/72IU at 12-18m.

Mean intakes for formula-fed infants aged 4-18m were therefore above the RNI up until 10 months. For breastfed infants, intakes of vitamin D from all sources (excluding breast milk) were well below the RNI at all age groups and according to the DNSIYC although only 6% had a clinical deficiency as measured by serum 25 (OD)D concentration of less than 25nmol/L, all of these infants were breast-fed. Following this report, the UK government changed its guidelines to recommend a vitamin D supplement to all breast-fed babies and that all children from 1 to 4 years should take a supplement of 10 mcg a day, due to the importance of vitamin D in growth, specifically bone formation and calcium metabolism. Vitamin D deficiency is linked to the development of rickets, the clinical presentation of bone and joint malformation due to lack of vitamin D during a child's growth (Francis, 2008). Osteomalacia, which presents as aching bones and muscles, is found in adults and adolescents who have vitamin D deficiency or problems with its metabolism for example due to chronic kidney disease (SACN, 2016).

Regarding supplementation, the 2010 Infant Feeding Survey found that 7% of babies 4-6 months and 14% of 8-10 month olds were receiving vitamin drops including vitamin D, with mothers from BAME backgrounds more likely to supplement than White mothers (McAndrew et al., 2012). In fact, at 8-10 months, 41% of Black mothers surveyed, 38% of Asian mothers and 33% of mothers of Chinese or other ethnicity gave vitamin D supplements to their babies, compared to just 10% of White mothers. This suggests that health promotion messages about the importance of vitamin D supplementation in ethnic minority populations are being heard and implemented.

2.5.4 Use of commercial versus home made products

Another key question is whether infants are being given home made fresh foods or are reliant on commercial baby food products, particularly because of the type of foods often included in the latter. Recent research has highlighted the significant use of sweet tasting sugary purees in commercial baby foods, which may have implications for infant nutritional intake, weight and longer term eating behaviour.

For example in 2013, a study by Garcia, Raza, Parrett & Wright surveyed all available commercial infant foods (479 in number) made by six UK brands. They found that 79% were ready-made spoonable foods, 44% were marketed as being for infants of 4 months and 65% of these were sweet in taste. Even among those which were classed as savoury, starch-based foods, 8.5% contained added fruit. Conversely home cooked foods tended to have a lower sugar content. This is potentially problematic as exposure to different tastes is linked to later food preferences in children (De Cosmi et al., 2017; Mennella, 2014; Nekitsing, Hetherington, & Blundell-Birtill, 2018; Ventura and Worobey, 2013).

Surveys of infants and toddlers' diets in other countries have found similar: a paper comparing commercial and home-made infant foods produced as part of the DONALD study in Germany, found that home-made savoury and "fruit-cereal" meals had a higher energy density compared to commercial equivalents, although it was found that "cereal-milk" meals both commercial and home-made had the highest energy density. The authors concluded that there was no inadequacy in either set of meals, although the commercial savoury meals had a higher sodium content than home-made foods, and in fact use of added salt at home was rare, which is reassuring (Hilbig, Foterek, Kersting, & Alexy, 2015).

Research examining the impact of commercial foods on longer term infant outcomes is sparse. One study found a correlation between the proportion of commercial foods eaten in infancy and later increased intake of added sugar and decreased intake of fruit and vegetables in preschool and primary aged children (Foterek, Hilbig, & Alexy, 2015).

2.6 How do experiences during pregnancy and the first year affect infant weight and eating behaviour?

Given the variation in infant diet, with many not meeting requirements or receiving unsuitable foods, a core question is to understand what factors are affecting nutrient and energy intake and affecting weight gain during the first year of life.

2.6.1 Pregnancy and prenatal factors

One of the earliest influences upon child health is their prenatal environment. In recent years, this has increasingly become a focus for research into the origins of obesity. The foetal origins hypothesis was developed from studies of the Dutch Hunger Winter of 1944, which suggested that intrauterine caloric deprivation had a lasting effects on adult health (Roseboom, de Rooij, & Painter, 2006). It was found that babies exposed to famine in early gestation had normal birth weight but higher levels of obesity and cardiovascular problems later in life than those exposed during mid-late gestation, who presented with reduced birth weights which tracked along similar lines during subsequent development, with reduced rates of adult obesity.

Some reasons suggested for these patterns include central nervous system development during the first trimester, which may influence abnormalities in appetite regulation centres, changes in placental growth and hormone output (Candler et al., 2019; Schulz, 2010). It has also been suggested that foetal adaptations to energy deprivation during pregnancy only manifest when the child is exposed to abundant food after birth. This is supported by differences seen between those who were exposed to similar famine conditions in utero but grew up in Holland (which recovered from the famine quickly) versus the USSR, where conditions were severe for a longer period of time (Schulz, 2010).

There is also an association between maternal BMI and infant birthweight. One recent UK study found that low birthweight (<2.5kg) was associated with both maternal underweight and overweight, although most closely with underweight, while macrosomia (birthweight of >4kg) has been associated most strongly with maternal obesity (Scott-Pillai, Spence, Cardwell, Hunter, & Holmes, 2013). However, it can be hard to disentangle the links between birthweight due to maternal under or overnutrition, from those that are social or environmental, as there is also evidence linking socioeconomic status with either low or high birth weight (Danielzik, Czerwinski-Mast, Langnase, Dilba, & Muller, 2004; McGovern, 2013; Reynolds et al., 2020).

Other epidemiological studies have found links between birth weight and later BMI, with both low and high birthweight being associated with obesity but low birthweight being particularly associated with increased central obesity (Oken and Gillman, 2003). Other investigations have suggested that the associations are more nuanced, with the finding that high birthweight is in fact linked to higher muscle mass, rather than body fat percentage, which cannot be distinguished using BMI alone (Wells, Chomtho, & Fewtrell, 2007).

In addition to birthweight, it has also been shown that early weight trajectories are influential on later adiposity, with rapid weight gain (RWG) in early infancy being highlighted as a potential factor. In a recent meta-analysis, RWG (defined as a change in z-scores of > +0.67) was found to start after six months of age, and led to those affected having 3.66 times the risk of being overweight or obese later in life (Zheng et al., 2018). In addition, the obesity risk was higher when RWG took place between 6-12 months as opposed to the second year of life, suggesting that a child's risk of overweight is affected by their earliest experiences of food and drink. Another paper from the UK Millennium Cohort found that BMI trajectories were higher in children who experienced RWG, and this difference was seen at 5 years of age, persisting into adolescence

Although the impact of the prenatal environment on fussiness and diet quality has not attracted as much attention from the research community as the impact on obesity, work on the area of flavour transfer and food acceptance has been carried out. Breast milk can transfer the flavours of a mother's diet (as well as nutrients) to the nursing infant. However, this also happens in utero via amniotic fluid: in one study a flavour experienced in utero (carrot) was more readily accepted by an infant when introduced to solids (Mennella et al., 2001).

It has been posited that this influence on flavour acceptance might also result in wider food acceptance in infancy. A recent systematic review of papers looking at flavour transfer during pregnancy and breastfeeding found that the flavours of several foods eaten during pregnancy (garlic, anise, carrot and alcohol) were recognised and accepted readily by infants after birth. However, the authors stated that this could not be generalisable to all foods in the maternal diet (Spahn et al., 2019). In addition, four studies examining the effects of maternal diet while pregnant on later diet quality and nutrient intake were considered in the review (Ashman, Collins, Hure, Jensen, & Oldmeadow, 2016; Jones et al., 2015; Lioret et al., 2015; Okubo et al., 2014) but the authors concluded that these studies did not take account of the maternal postpartum diet on infants' intake and biased reporting of maternal and child intake and therefore there was no evidence for the effect of maternal prenatal diet. More research is needed to clarify these points. Clearly, it is preferable for mothers to eat a wide variety of healthy, flavourful, nutrient dense foods during pregnancy but this is not always possible due to financial constraints and the nausea experienced by many women during pregnancy, which can often limit the types of foods eaten (Lee and Saha, 2011).

2.6.2 Milk feeding

Infants require either breast milk or an infant formula as their only source of nutrition for the first six months of life (WHO, 2002). Many studies have suggested that breast feeding gives protection from later obesity, including Kramer's seminal case-control study of 1172 adolescents, which found a protective effect which persisted when confounders were controlled for (Kramer, 1981), while several systematic reviews and meta-analyses have found positive associations between breast feeding and reduced risk of overweight and obesity (Armstrong and Reilly, 2002; Rito et al., 2019; Weng, Redsell, Swift, Yang, & Glazebrook, 2012; Yan, Liu, Zhu, Huang, & Wang, 2014).

One mechanism for these findings is the lower protein content in breast milk compared to infant formula. The "early protein hypothesis" (Koletzko et al., 2009) proposes that excess protein intake increases insulin, IGF-1 and other growth factors leading to increased fat deposition and weight gain. The authors of the Australian NOURISH RCT hypothesised that the higher protein content of formula or the method of feeding, may be responsible for the rapid weight gain seen when 612 infants were assessed for weight and infant feeding practices. After adjusting for confounders, there were only associations with RWG for formula feeding, feeding to a schedule, male sex and low birth weight (Mihrshahi, Battistutta, Magarey, & Daniels, 2011).

As well as its protective effects on obesity, breast feeding has also been associated with an increase in healthy eating behaviours such as food acceptance and satiety responsiveness (Brown and Lee, 2012; Horta and Victora, 2013; Maier, Chabanet, Schaal, Leathwood, & Issanchou, 2008; Mennella et al., 2017; Pang et al., 2020). One reason posited for these benefits is the responsive nature of breast feeding. Infants have greater control over their intake of milk when feeding from the breast rather than being fed from a bottle (Savage et al., 2018; UNICEF, 2016). This may support the development of more satiety responsive eating behaviour and indeed breastfeeding for as little as six weeks has been found to increase satiety responsiveness at 18-24 months in one UK study (Brown and Lee, 2012).

Another possible benefit of breastfeeding with regard to an infant's relationship with food is reduced neophobia or food fussiness. Breast milk has the benefit of being variable in flavour dependent on the mother's diet. A series of studies by Mennella et al have demonstrated this adaptation and how exposure to different flavours in breast milk, and amniotic fluid when the infant is in utero, can change an infant's acceptance and preference of foods during the weaning process (Mennella and Beauchamp, 1993, 1999; Mennella et al., 2017), as mentioned in the previous section.

Breast feeding has also been linked with reduced food fussiness in studies looking at older children (Galloway et al., 2003; Pang et al., 2020; Specht, Rohde, Olsen, & Heitmann, 2018). Galloway et al (2003) found a positive association between breast-feeding for less than 6 months and picky eating in 7-year-old girls, while a cohort study from Singapore, Pang et al (2020) found that a "high" breast feeding group (full breast feeding for four months, continuing in any degree for at least six months) was associated with lower food fussiness at 3 years of age. This was not seen with shorter patterns of breast feeding. The reduced fussiness in this group was found to continue at 6 years of age although the difference between groups was not significant. A US paper looking at preschool children found that both a lack of exclusive breastfeeding and the introduction of complementary foods before 6 months increased the risk of picky eating (Shim, Kim, & Mathai, 2011).

There is also evidence that breast feeding may be linked to improved diet quality and increased acceptance of healthy foods in pre-schoolers. In a large analysis of four European cohort studies (including the UK ALSPAC cohort), an association was found between healthy dietary variety at 2 and 4 years of age and breastfeeding for 3-6 months, as opposed to never breastfeeding or early cessation, independent of age of solid food introduction or maternal education. However, it should be mentioned that none of the children studied ate the recommended 5 different healthy food groups each day (Jones et al., 2015). In addition, the previously cited Danish study by Specht et al (2018) found that as well as being less fussy, infants exclusively breastfed for 6-10 months had a higher intake of vegetables at 2-4 years.

2.6.3 Timing of introduction to complementary foods

As noted above, it is recommended that infants receive solid foods at around 6 months of age. This offers the greatest protection against respiratory and gastrointestinal infections whilst not compromising infant growth (WHO, 2001). However, another benefit is that timing of introduction of solid foods may affect infant weight and eating behaviour, although the causal direction of this relationship is difficult to disentangle. This area is also disadvantaged by a relatively sparse number of studies exploring the association between timing of solid foods and infant outcomes compared to areas such as milk feeding.

Introducing solid foods before six months is often associated with non-responsive feeding strategies. In the UK Infant feeding survey in 2010 numerous reasons were given for an early introduction of solid foods including being unsettled and unsatisfied with milk and waking at night. Solid foods were given in the belief that they would 'settle' infants and make them sleep for longer (McAndrews et al, 2012). This approach has also been identified in other research. A UK study with 756 mothers investigating reasons behind the introduction of solids found that a perception that their baby was hungry, or wanted to eat or to settle behaviour and encourage sleep were common reasons given (Brown and Rowan, 2016). Similar findings were identified in research with 1035 mothers in Australia (Arora et al., 2020). Finally, in the Infant Care, Feeding and Risk of Obesity Study in the US, infants who were perceived as fussy, were more likely to be given solid foods early, most likely in an attempt to reduce and soothe their fussiness (Wasser et al., 2011). Essentially parents are attempting to meet normal infant behavioural needs of frequent milk feeding and waking with food, potentially encouraging dysregulation of appetite control.

An earlier introduction to solid foods is also associated with using a more controlling maternal child feeding style. In the NOURISH trial in Australia, mothers who introduced solid foods early were less aware of infant cues of hunger and satiety and were more likely to use food to try and calm their baby (McMeekin et al., 2013). Likewise, in another study in the US, mothers who reported an early introduction of solid foods were less likely to respond to their infants hunger cues and be responsive in their feeding styles compared to those who waited until after six months (Doub et al., 2015).

Infant birth weight also plays a role with mothers adapting their feeding approach according to infant size. Infants who are heavier at birth are more likely to receive solid foods early, potentially because of beliefs that a bigger baby needs more than milk can give, despite ironically most weaning foods being lower in energy and nutrient density than breast or formula milk (Rogers and Blissett, 2019). Indeed mothers continue to react to infant size. One study amongst mothers with a baby age 6 – 12 months found that those with a larger infant were more likely to report restricting food whereas those with a lighter infant used greater pressure to eat (Brown and Lee, 2011b).

An earlier introduction to solid foods is also associated with offering less nutrient dense foods. For example, the recent BeeBOFT study of early feeding for 2157 Dutch infants found that 21.4% of infants had received solids before 4 months of age. Common early foods included sugary drinks and savoury snacks (Wang et al., 2019). This pattern was also reflected in the UK Infant feeding survey where foods given to infants before six months were more likely to be sugary and starchy foods such as rusks (McAndrews et al, 2012). This is potentially very important as longitudinal research from the Infant Feeding Practices Study II and Year 6 follow up studies found significant associations between infant diet and child diet. Where fruit and vegetable intake was higher at 9 months, it was also higher at 6 years and vice versa. Conversely when sugar and saturated fat intake was high at 9 months it was also high at 6 years and vice versa (Rose, Birch, & Savage, 2017).

These factors in themselves could all work together to potentially affect infant eating behaviour and weight. However, in terms of whether an early introduction affects infant eating behaviour, the results are sparse and mixed, focusing predominantly on fussy eating. For example, a recent paper from the Dutch Generation R study found that at age four, children who had been introduced to vegetables at 4-5 months were less fussy than those who had been introduced to them after 6 months, although introducing other foods early had no effect (de Barse et al., 2017). Earlier research showed that introduction of lumpy foods after 7 months increased texture aversion into childhood (Coulthard, Harris, & Emmett, 2009), while others have suggested a sensitive period for taste acceptance as 4-5 months of age (Mennella and Beauchamp, 2005). Research on timing of solids and food acceptance has been limited but there is evidence that introduction of vegetable tastes early in weaning seem to promote flavour acceptance (Blissett and Fogel, 2013; Maier et al., 2008).

For satiety responsiveness, research is sparse in terms of timing. One longitudinal study in the UK (Brown and Lee, 2015) found that an earlier introduction of solid foods was associated with lower satiety responsiveness at 18 – 24 months. However this was confounded by method of introducing solid foods meaning the findings are not clear (for more details see the next section on baby-led weaning).

Finally, in terms of infant weight, the findings are mixed. Two systematic reviews of the association between timing of solids and later infant weight are inconclusive with some studies showing an earlier introduction is associated with increased risk of overweight whilst others show no link. Where introduction is very early (before four months) there tends to be a stronger link with increased risk of overweight (Moorcroft, Marshall, & McCormick, 2011; Pearce, Taylor, & Langley-Evans, 2013).

2.7 The impact of how infants are introduced to solid foods and growth of "baby-led weaning"

Alongside timing of introduction to solid foods, in recent years the topic of how babies receive solid foods has received much greater attention. When guidelines to introduce solid foods were based on younger infants, spoon feeding of soft infant foods was necessary. However, once guidelines changed to six months of age, a different approach known as 'baby led weaning' started to emerge. Here infants self-feed family foods in their whole form rather than being given special infant foods on a spoon. The question arises – does this approach have any impact on infant eating behaviour, nutrient intake and weight?

The term Baby Led Weaning was first used by Gill Rapley in an unpublished Master's thesis in 2003. Although there is no formal definition of BLW, its characteristics include:

food being offered as whole finger food (not pureed or mashed), babies self-feeding by bringing food to their own mouths rather than being fed by a caregiver and infants joining in with family meals and eating family foods as soon as they begin weaning (Brown and Lee, 2011a). Baby led weaning as a method appears to be a feasible way for infants to be introduced to solid foods. Most babies are developmentally ready for self-feeding at around six months, (barring prematurity and other factors which may delay development) (Cameron, Heath, & Taylor, 2012b; Wright, Cameron, Tsiaka, & Parkinson, 2011).

Although no study has attempted to document the proportion of parents using BLW across a population, growing numbers of parents appear to be using BLW, given its presence in online discussion forums and discussion groups. A simple Google search for baby-led weaning produced 8,440,000 hits (17.09.2020), while there are many baby-led weaning Facebook groups, some having over 100,000 members, as of September 2020. The method appears to be more prevalent amongst mothers who breast feed, have a higher educational level, higher employment status and those who are married (Brown, 2015; Brown and Lee, 2011a; Brown and Lee, 2015; Fu et al., 2018).

A number of studies have explored perceptions of the baby-led method amongst mothers who have chosen to follow it. There is a strong perception among those that use the approach that it has a positive impact upon infant weight and eating behaviour. Mothers perceive it as offering infants a gentle introduction to solid foods, placing them in charge of their mealtimes. Others believe that foods in their 'real' form are more palatable and enjoyed by infants. This is all perceived to have a positive impact on protecting infants against overweight and encouraging the development of satiety responsive, adventurous eating (Arden and Abbott, 2014; Brown and Lee, 2013; Cameron et al., 2012a; D'Andrea et al., 2016)

From a logical perspective, components of the BLW approach fit with what we know encourages healthier eating habits in infants. For example, by its nature, BLW may encourage a later introduction of solid foods closer to six months of age. Infants are unlikely to be able to developmentally self-feed foods before around this period. Indeed, most studies exploring BLW have shown a later introduction of solids compared to infants being spoon-fed show BLW infants are introduced to solid foods later than their spoon fed peers (Brown and Lee, 2011a; Komninou, Halford, & Harrold, 2019; Morison et al., 2016).

Next, a core element of BLW is that infants have greater control over their intake of food. They self-select foods (from those offered) and are in control of the pace and amount eaten. Conversely spoon-fed infants have less control over the pace of the meal and may have their subtle cues of fullness ignored by parents eager for them to finish the meal. Indeed, one study which compared the feeding style of mothers using baby led or spoon-fed approaches found mothers who followed BLW reported lower levels of controlling child feeding practices compared to those spoon feeding (Brown & Lee, 2011c). As noted previously, a controlling maternal child feeding style can be associated with a number of negative outcomes for children for both weight and eating behaviour.

However research actually examining whether this potential impact is growing but still inconclusive especially in some areas. A number of interesting studies have been published, although many are cross sectional in nature and rely on self-selecting participants who have chosen a baby led or spoon feeding approach, meaning that their generalizability is weaker and confounded by other factors such as maternal demographic background and own eating behaviour. Much of the research conducted has emerged from two teams in the UK and New Zealand, although some research has been published form other regions (Brown et al., 2017).

There has been one main randomised controlled trial of methods of introducing infants to complementary foods. The BLISS (Baby-Led Introduction to SolidS) study was a two year randomised clinical trial of a modified form of baby-Led Weaning, devised by a team from Otago University in New Zealand and tested with a pilot study of 23 infants (Cameron, Taylor, & Heath, 2015). Following this trial, a larger scale study took place following infants who were assigned to either a control (n = 101) or BLISS intervention group (n = 105). Those in the control group were advised to introduce solid foods as 'usual' whilst those in the BLISS group received guidance on following an adapted version of baby-led weaning to introduce solids to their baby. This included offering high energy and iron rich foods to reduce some of the concerns around infants not being able to self-feed sufficient nutrients. Lactation support was also given to encourage exclusive breast feeding and delay the introduction of solids to six months. Outcomes for infants were compared at 12 and 24 months of age (Taylor et al., 2017).

A similar RCT has recently been carried out in Turkey with 280 infants (BLW: n = 142, TSF: n = 138), primarily comparing infant growth, iron intake and haematological parameters between weaning groups at baseline (7 months) and 12 months of age. Parents of all infants in the study were educated on iron-rich and iron-fortified foods to offer their children, while those randomized to the BLW group received extra training and support on the BLW method, including recipe books and home visits from trained research staff (Dogan et al., 2018).

Taken together, what have these studies found for how weaning method affects infant eating behaviour, weight and dietary intake?

2.7.1 Baby led weaning and weight

One important aspect of research is whether weaning approach affects infant weight in the short and long term. As noted above, parents believe that BLW may promote a healthier weight gain trajectory by allowing infants to self-feed and set the pace and intake of their meal. A number of studies have sought to explore this belief. The results however have been mixed and complicated by different study designs, each with their own limitations.

The first study to be published on BLW and weight examined differences in pre-school children's weight dependent on whether they followed a baby led or spoon fed approach as infants. It found that those who had followed a BLW approach were significantly lighter than those who used a TW approach. BLW were less likely to be overweight compared to TW infants but also more likely to be underweight. However the vast majority of infants were a healthy weight: 81% of BLW and 84% of TW infants. There were a number of limitations with this study including recall of weaning method, some self-reporting by parents of child weight and a lack of control for other confounding factors such as breastfeeding and feeding style (Townsend and Pitchford, 2012).

Another study looked at longitudinal weight outcomes amongst infants following BLW or TW approaches. Mothers reported weaning approach at 6 – 12 months and then infant weight at 18 – 24 months. No differences in weight between the two groups were found at birth or 6 months but TW infants were significantly heavier at 18–24 months compared to those using BLW. This difference persisted when birth weight, maternal weight, length of breastfeeding and child-feeding style were accounted for. However, weights were self-reported by mothers (Brown and Lee, 2015).

Examining data from the BLISS RCT study, there was no significant difference in BMI between infants at either 12 or 24 months (Taylor et al., 2017). However there are a number of reasons why a difference in weight may not have been found. Not all parents adhered to their prescribed group. Some parents in the BLW group introduced purees and spoon-feeding whilst some who were left to follow a standard approach gave a high proportion of finger foods. An intention to treat analysis was used meaning that similarities between the groups in terms of weaning approach may have masked outcomes. Additionally, the guidance given to ensure energy rich foods such as avocado were offered daily (to reduce concerns over weight faltering) may have led to an adapted BLW being followed, increasing calorie intake and reducing the protective effect of BLW.

However, in the recent RCT in Turkey, a significant difference in weight outcomes between weaning groups was found. Infants in the baby-led group weighed significantly less (mean 10.4Kg) than a traditionally weaned control group (mean 11.1Kg) at 12 months, and all cases of overweight were found in the spoon feeding group (17% of the group). One limitation of this study was the absence of checks on adherence to the prescribed weaning methods and only breast fed babies were included on the study. The growth rate of formula fed infants may well have been different (Dogan et al., 2018).

Finally and most recently, a study of 269 3-12 month old infants in south Wales, explored BMI and associations with milk feeding and weaning style (Jones, Lee, & Brown, 2020). The researchers found initially that there was no difference in weight or BMI between infants who were spoon-fed and self-fed, however, when milk feeding style was taken into account, there was a significant difference in infants spoon-fed and self-fed when the infants were formula fed. Infants who were both spoon-fed and bottle-fed had a higher BMI than infants who were spoon-fed and breastfed, BLW and bottle-fed or BLW and breastfed. Although mothers in the study self-selected their weaning group, weight measurements were taken by the research team. The findings highlight the importance of looking at both parts of infant diet (milk and solids) and suggest that opportunity to self-regulate for at least one of those is important.

2.7.2 Baby led weaning and satiety responsiveness

A second focus of research examines the impact of weaning approach upon infant eating behaviour. A number of studies have now explored the association between approach to introducing solid foods and infant satiety responsiveness, although a limitation of this research is that this measure is typically based on parents self-reporting infant satiety responsiveness.

First, in a longitudinal study exploring eating behaviour and weight amongst infants following different weaning approaches, toddlers who had been introduced to solids using a baby-led approach were rated by their mother as better able to respond to their own satiety compared with traditionally weaned children. Notably in this study other potential confounding factors were controlled for including maternal child feeding style, timing of introduction to solid foods, and breastfeeding duration. BLW was independently associated with a greater ability to be satiety responsive (Brown and Lee, 2015).

However, other studies have not supported this. Results from the BLISS research trial in New Zealand found the reverse: infants using their modified form of BLW were less satiety responsive than those weaned using traditional methods (Taylor et al., 2017). Conversely, a cross sectional UK study of five hundred and sixty five parents of toddlers aged 12-36 months, found no difference in satiety responsiveness between those who chose to follow a baby-led or traditional spoon feeding approach (Komninou et al., 2019).

2.7.3 Baby led weaning and infant fussiness

Another area of research has explored the impact of weaning approach upon infant fussiness. Parents perceive that the BLW approach encourages food acceptance in infants as foods offered are more palatable in whole form, easily identifiable and self-feeding more enjoyable than being self-fed. In terms of the research this is indeed one area where research appears to support parental beliefs. Both self-selecting studies in the previous section (Brown and Lee, 2015; Komninou et al., 2019) found that parents following a BLW approach rated their infants as less fussy than those using spoon-feeding, although an early UK study found no difference (Townsend and Pitchford, 2012). However their examination of this topic was limited, simply asking parents if they considered their child to be a 'picky eater'.

Research from New Zealand also supports the concepts of BLW being associated with reduced fussiness. In a cross-sectional internet survey of six hundred and twenty-eight parents from New Zealand, lower food fussiness in babies and toddlers aged 6-36 months who had been introduced to solids using BLW was reported. The effect was particularly strong in those who had used a "strict" BLW method rarely using any spoon feeding or purees in contrast to those who had used a more relaxed approach (Fu et al., 2018). The BLISS trial also found that perceived fussiness was significantly lower in BLW infants when measured using the CEBQ and Toddler-Parent Mealtime Behaviour Questionnaire (TMBQ) at 12 months but this difference had disappeared by 24 months (Taylor et al., 2017).

In terms of food acceptance, there has been little research exploring the impact of weaning approach on this outcome. One previously cited UK study did explore perceived food preferences of pre-school children who had followed different weaning approaches, finding that those who had followed a BLW approach had a preference for starchy carbohydrates, whilst those in the spoon-fed group preferred sweet foods (Townsend and Pitchford, 2012).

There are a number of reasons why a BLW approach might affect infant fussiness and food preferences. As noted above, the process of being able to select food and self-feed might promote food acceptance. Research with older children has found that a controlling maternal feeding style is associated with increased fussy eating in children. Pressurising children to eat often has the reverse impact instead reducing consumption (Benton, 2004). Parents who follow BLW naturally adopt a feeding style lower in control as there is less opportunity to do so. It is also likely that foods in their whole form may be more appealing and tempting for infants to try (Brown and Lee, 2011c). It is also possible that this association is not causal. Potentially infants who are fussier eaters resist the introduction of solid foods and parents decide that a spoon-feeding approach is necessary (Brown, 2015; Brown and Rowan, 2016).

2.7.4 Does baby led weaning affect infant diet?

The studies above have predominantly focussed on infant weight and eating behaviour but an important question is whether BLW affects nutrients consumed. There are two core questions here: is baby led weaning sufficient and what is its impact upon diet consumed in terms of energy, macro and micronutrients? Although we know that BLW infants are less likely to be perceived as fussy, does this actually correlate with diet consumed or is it simply a perception? Likewise, although results are mixed in terms of impact upon weight, does a more satiety responsive eating approach reduce the risk of over consumption of energy?

Research in this area is relatively underdeveloped compared to a focus on weight and eating behaviour outcomes with much of the research emerging from one research group in New Zealand. In terms of research that has examined differences in intake of different food groups:

- In a paper from the BLISS study looking at iron intake and dietary modifiers such as phytate and vitamin C, the only significant difference intake was seen in vitamin C intake at 7 months, presumably from fruits and vegetables, where the control group had a higher intake than the BLISS group. (Daniels, Taylor, Williams, Gibson, Fleming, et al., 2018). In a separate study from the same research group at 7 months of age, BLW infants were found to consume significantly more grains/cereals, meat and meat alternatives, and more dairy products. However, these differences disappeared by 12 months. Likewise BLW infants consumed less saturated fat at 12 months but not by 24 months. Notably both groups consumed excess sodium and added sugars at 24 months (Williams Erickson et al., 2018).

- A small cross sectional study in New Zealand used parental questionnaires and a weight food diary to examine nutrient intake in a small group of infants and toddlers aged 6 – 36 months (n = 51) following BLW and TW approaches. They examined intake of iron-fortified cereal, red meat, sugary foods, high sodium foods, fruit, vegetables and commercial baby foods. The only significant differences were in iron-fortified cereal consumption, which was consumed by a higher percentage of the traditional spoon feeding (TSF) group (Morison et al., 2016)

- Also from New Zealand, another study comparing 155 full BLW, 93 partial BLW and 628 TSF (spoon-fed) infants, found that BLW babies were much less likely to have had iron-fortified baby cereal at 6 months of age but were much more likely to have eaten red meat (Fu et al., 2018). Interestingly, this study found that full BLW infants were less likely to consume "more fruits than vegetables" at the start of solid food introduction when compared with the TW group i.e. vegetables were offered more than fruits.

- In terms of food variety, the BLISS study asked parents to complete three days weighed food diaries at 7, 12 and 24 months . They found that at 7 months, the BLW group ate a greater variety of foods of different types, but by 24 months the only significant difference to remain was in the variety of fruits and vegetables eaten (Morison et al., 2018).

- A recent British study compared 88 BLW infants and 46 TW infants using a Food Frequency Questionnaire and 24 hour recall. They found that the TW group were more likely to be offered infant cereal and salty snacks at 6-8 months, dairy products at 9-12 months and commercial baby foods in both age groups (Alpers, Blackwell, & Clegg, 2019).

Other studies have focused on micronutrient intake, particularly around zinc and iron status:

- In the BLISS study no significant differences were found in intake of zinc or iron at 7 and 12 months as measured by 3 – day weighed food diary records. This was followed up by examining levels in blood plasma at 12 months through blood tests, finding no significant differences at 7 or 12 months of age (Daniels, Taylor, Williams, Gibson, Samman, et al., 2018).

- In the Morison et al (2016) study above, those following BLW consumed more sodium but less iron, zinc, calcium, vitamin C, vitamin B12 and fibre than traditionally weaned infants.

- In the RCT from Turkey, no differences were found between weaning groups at 12 months of age for serum iron markers or iron consumption (Dogan et al., 2018). Iron intake from complementary foods was 7.97 mg in the BLW group and 7.90mg in the spoon-feeding group, compared to the Turkish RDA for 12 months of age set at 11mg. However, as previously discussed, parents of all infants in the study were educated on iron-rich and iron-fortified foods to offer their children.

Finally in terms of energy intake:

- The BLISS study found no significantly different energy intakes between the BLW and control groups at any stage of the study (Taylor et al., 2017). At 7 months, the control group had a mean energy intake from the whole diet of 684 kcal vs. 716 kcal in the BLW group. At 12 months this was 864 kcal and 866 kcal respectively, while at 24 months energy intake was 976 kcal in the control group and 962 kcal in the BLW group.

- In the Morison et al (2016) three day weighed food diary study no significant differences were found in energy intake at 6-8 months, with the traditional spoon feeding group consuming 692 kcal, a partial BLW group having an intake of 734 kcal and the full BLW group consuming 669 kcal.

2.7.5 Does baby led weaning ensure sufficient nutrient intake?

The studies detailed above highlight that few differences have been found in infant nutrient intake dependent on weaning group. However they are relatively limited in number, coming predominantly from the New Zealand based team. At the time of initially writing this literature review, no study had yet examined nutrient intake of infants following BLW or traditional weaning approaches in the UK, although Alpers et al (2019) have since published their Food Frequency Questionnaire and 24-hour recall study. This study did not however measure specific food intake in terms of macro and micronutrients and overall energy consumed, instead looking at consumption of different food types.

This lack of research around infant nutrient consumption is an important area to potentially explore further as it is a main concern of health care professionals in other countries when it comes to the BLW approach to starting solid foods. For example, Cameron et al (2012) explored health professionals' attitudes to baby-led weaning using in-depth interviews. They found that almost half of all the respondents had heard of the approach. When details about the method were provided, all participants could see benefits for the family and child such as greater exposure to a variety of foods, joining in family meals and self-regulation of appetite. However, common concerns were raised around the possibility of choking, failure to thrive, poor food choices and reduced iron intake.

Likewise a qualitative study in Canada looking at experiences of mothers (n = 65) and views of health care providers (n = 33) found that most of the HCPs (81.8%) had heard of BLW and were aware that it involved the baby feeding themselves whole, unpureed foods. (D'Andrea et al., 2016). More than 80% of the HCPs believed BLW promoted fine and oral motor skills and encouraged family mealtimes. Most also believed that it would encourage healthier eating, help infants respond to internal satiety cues and was more convenient. However, again, they also said BLW would increase the risk of choking

(69.7%), parental anxiety (57.6%) and might lead to inadequate energy (36.4%) and iron intake (39.4%).

Health professionals in other countries clearly have concerns regarding the nutrient intake of infants following a baby-led approach. However, no research has explored perceptions of UK health professionals in the same way. Likewise, apart from the now published Alpers et al (2019) study, although a number of papers exploring the impact of BLW upon infant weight and eating behaviour have been led by UK researchers, no other study has explored what babies following the approach are actually eating. Moreover, as noted above the Alpers et al (2019) study did not collect sufficiently detailed data as to be able to calculate nutrient and energy intakes.

Taken together this literature review points to the research gap around infant dietary intake by different weaning approaches within a UK context. Although findings from regions such as New Zealand are useful, context matters when it comes to nutrition and eating behaviour research. It is important to understand what UK infants are eating and how this might be linked to weaning approach. Therefore, the overarching aim of this thesis is to answer the question:

'*Does nutrient intake differ according to whether infants are following a baby-led weaning or traditional spoon-feeding approach?*'

To answer this a series of studies will be conducted to explore perceptions of infant eating behaviour and food preferences, food exposure, and macronutrient, micronutrient and energy intake according to whether infants are following a baby-led or traditional weaning approach. The first step of this thesis is to draw on research in Canada and New Zealand to explore whether health professionals in the UK also hold concerns around infant nutrient and energy intake according to weaning approach. Based on confirmation of similar concerns, the remainder of the thesis will explore food preferences, exposure and intake between weaning groups. Overall, it seeks to answer the following research questions:

R1. Do UK healthcare professionals have concerns about dietary intake and weaning approach?

R2. Does eating behaviour and food acceptance differ between weaning groups?

R3. Are there differences in energy intake between weaning groups?

R4. Are there differences in macro/micronutrient intake between groups?

R5. Is BLW sufficient or significantly different to traditional weaning?

Chapter 3: Overarching methodology of the thesis

Introduction

This chapter describes the research methodologies within this thesis and the rationale behind the study design. An overview of the aims and objectives and the research design are followed by a description of specific tools and methods used and a discussion of the strengths and limitations of the research design. The chapter is concluded with a discussion of reflexivity from the author and the impact or otherwise of any personal bias on the results of the studies.

Aims and objectives of the thesis

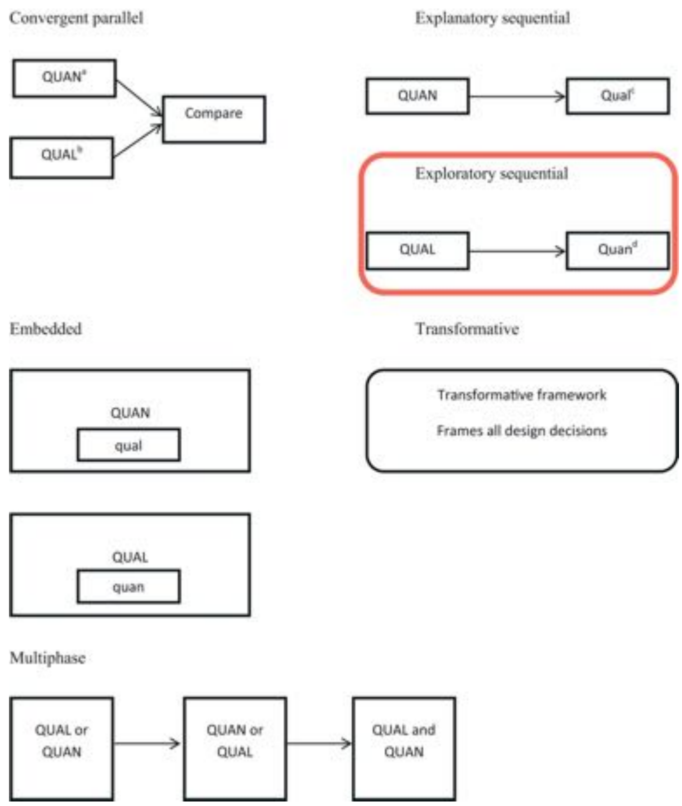
This first aim of this thesis was to explore attitudes to the baby-led approach among UK professionals working with infants and parents, followed by an examination of the energy and nutrient intake of infants introduced to solids using baby-led weaning, particularly when compared to those weaned using traditional methods. As well as intake, research focused on eating behaviours, particularly around food acceptance and investigating whether BLW sufficient for growth and development and whether it is significantly different to traditional weaning. These aims were synthesised in the following research questions, which underpinned the studies within this thesis.

R1. Do UK healthcare professionals have concerns about dietary intake and weaning approach?
R2. Does eating behaviour and food acceptance differ between weaning groups?
R3. Are there differences in energy intake between weaning groups?
R4. Are there differences in macro/micronutrient intake between groups?
R5. Is BLW sufficient or significantly different to traditional weaning?

Overview of the thesis research design

The overarching research design for this thesis was a mixed methods approach incorporating qualitative and quantitative analysis and a range of different data collection tools. There are several ways mixed methods research may be structured as shown in figure one below: convergent parallel, explanatory sequential, exploratory sequential, embedded, transformative and multiphase (Zoellner and Harris, 2017).

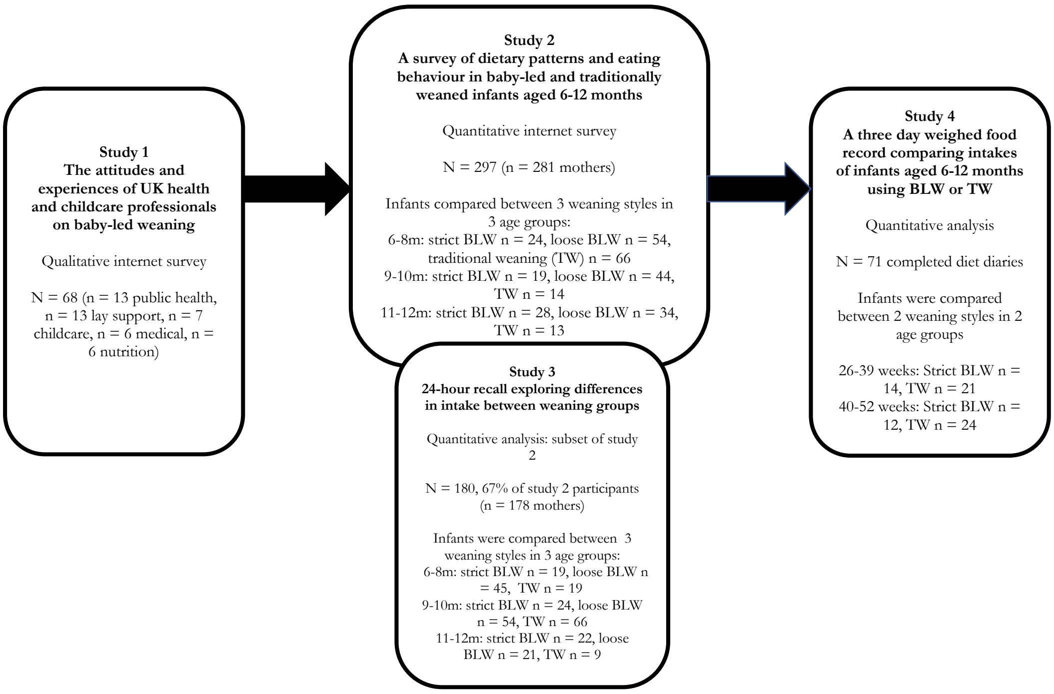
Figure 2: Examples of mixed methods study design structure (Zoellner and Harris, 2017)



For this thesis, the design chosen was exploratory sequential, as highlighted in figure one, because an initial qualitative study was used to explore and provide insight into how baby-led weaning was viewed by those working with parents and infants using an open-ended survey of health and child-care professionals to. Following this qualitative study of professionals, a series of three quantitative studies took place to examine nutritional intake and eating behaviours of infants being introduced to solids, comparing a baby-led and traditional, spoon-fed, approach. Studies two and three were drawn from data from the same survey, with a smaller proportion of participants completing one section of the survey (a 24 hour recall). Reasons for this smaller number of participants are examined in chapter six. The design of the thesis is presented in Figure two.

This staged pattern of data collection and analysis allowed the observed outcomes of following a BLW approach to be compared with the attitudes, experiences of concerns of health professionals that emerged from study one. It effectively allowed their concerns to be 'tested'. This pattern of data collection whereby the three latter studies addressed some of the findings of study one also ensured that the research was relevant to current professional concerns rather than gaps in the literature alone, thus adding to its real world application.

Figure 3: Schematic of studies within the thesis



Design and sampling strategies

The data collection strategies for mixed methods research can be described as either within-strategy or between-strategy (Tashakkori and Teddlie, 2009). The former refers to gathering data for both qualitative and quantitative studies using the same data collection strategy, for example a survey which gathers the two types of data. A between-strategy approach is when data is collected using different strategies. Between-strategy data collection was used in this thesis, with the survey of professionals collecting qualitative data regarding opinions and experiences of BLW, while the other studies collected quantitative data related to infant intake. Additionally, mixed methods research can involve gathering data at a single or on multiple levels (Tashakkori and Teddlie, 2009). For example, targeting parents of infants aged 6-12 months is an individual or single-level strategy, and was used in this set of studies. A multiple-level strategy might consist of interviewing parents and their health visitors but this strategy was not used here.

Sampling strategies used in nutrition and social science research typically include probability, purposive, snowball and convenience sampling (Tashakkori and Teddlie, 2009). Probability sampling is often used in quantitative research and involves random sampling of a population to achieve a representative cross-section of participants; purposive sampling is associated with qualitative research as it mean selecting subjects based on a specific requirement. Convenience sampling selects those who are easy to access and willing to participate, but may not be representative. Snowball sampling is when participants are acquired from those who have already taken part and is also non-probabilistic in nature. Mixed methods typically uses a combination of sampling techniques and in this instance, a combination of methods using social media (probability/snowball) and targeted email lists/visiting baby groups (purposive) to advertise the studies.

Analysis procedures for mixed methods revolve around cross-validating or combining data from both qualitative and quantitative work (Creswell and Plano Clark, 2018) and can be described as parallel, conversion, sequential and integrated procedures (Tashakkori and Teddlie, 2009). For example, in parallel analysis, qualitative and quantitative data is analysed and interpreted separately, then the two sets of conclusions are considered together. This thesis used parallel analysis as the themes around BLW exposed by the professionals study were considered in tandem with the quantitative results of the intake studies. This thesis also used conversion analysis, which is the converting of qualitative data generated in the professional study, to codes and counts (quantising) (Creswell and Plano Clark, 2018).

The inference process for mixed methods research, that is the way in which meaning is derived from results, is one of the benefits of using a mixed methods approach (Tashakkori and Teddlie, 2009; Zoellner and Harris, 2017). Specifically, the quality (internal validity, referred to as credibility in qualitative research) and transferability (external validity) of the study conclusions, as discussed in chapter four regarding trustworthiness.

Philosophical assumptions underpinning the research design

The philosophical assumptions which form the foundation for the research being undertaken should be considered by the researcher before work is undertaken (Creswell and Plano Clark, 2018). One matter that should be addressed in this preliminary work is the research paradigm or belief system adhered to. This is "the set of beliefs and practices that guide a field" (Morgan, 2007), and in practical terms will determine the nature of the data collection tools and type of analysis chosen (Guba and Lincoln, 1994). The fundamental elements that make up a research paradigm are its ontology: the beliefs and theories about the nature of the reality being investigated, epistemology: how knowledge about that reality is created, and methodology: how data is collected (Bergman, 2008).

There are several commonly used paradigms in health, psychology and social care research, outlined below (Creswell and Hirose, 2019; Creswell and Plano Clark, 2018; Doyle, Brady, & Byrne, 2009):

- Positivism: This is associated with the objective, quantitative measurement of numerical data, performing statistical tests on these data, producing empirical results. A positivist framework is often seen as the most objective form of research enquiry, with the assumption that there is a single reality which is being assessed (Creswell and Hirose, 2019; Morgan, 2007).

- Constructivism: Associated with qualitative research, this is described as subjective and interpretivist, in that the researcher is letting participants (the objects of study) describe their situation and the researcher interprets and constructs "reality", acknowledging that a single reality is therefore non-existent as the involvement of the researcher in interpretation will shape the reality of the subjects of enquiry to an extent (Yvonne Feilzer, 2010).

- Pragmatism: This approach has evolved in an effort to employ the most useful aspects of both positivism and constructivism in a mixed methods design, in the belief that combining the knowledge produced by quantifiable and experiential data, will produce greater insight into a topic by bridging the gap between the two paradigms (Shannon-Baker, 2016).

Quantitative research was the dominant method for scientific enquiry in the post-war era, but qualitative methods became more widely used and accepted in the 1980s, when they were initially labelled "naturalistic enquiry" (Guba and Lincoln, 1982), since interviews were often carried out in a natural setting. First published in 1988, Bryman's "Quantity and quality in social research" was one of the first attempts at demonstrating the benefits of integrating the two forms of research, which as outlined in the section above, had previously been seen as distinct methods with different philosophical and practical underpinnings (Bryman, 2003). Following this, the 1990s saw the application of mixed methods gaining popularity as a research paradigm (Creswell and Hirose, 2019).

Although there is debate amongst researchers as to how mixed methods can be implemented, pragmatism is a popular framework as it overcomes the narrow views of a positivist framework (that reality can only be uncovered using quantitative data and large sample sizes) and those of the constructivist paradigm (documenting and interpreting the experiences of those familiar with the research subject) by bridging the gap and highlighting the best of both methods. Because of this, a pragmatic, mixed methods approach using both qualitative and quantitative procedures to explore baby-led weaning, was used for this thesis.

Benefits and challenges of a mixed methods design

Like all research paradigms, the mixed methods approach has benefits and challenges to researchers as outlined below.

Benefits

The overarching benefit of mixed methods is that it presents the best of both worlds because combining methods harnesses the strengths of each technique, which reduces their inherent weaknesses. For example, quantitative research may not highlight the way people actually live but the researcher is (or should be) uninvolved in the data, whereas in qualitative research, the focus is on the lived experience of the participants but due to its interpretive nature bias from the researcher may be brought in (Creswell and Plano Clark, 2018). Mixed methods work reduces the potential negative impact of the individual methods by bridging the gap between them, acknowledging that in spite of their differences all research methods are looking for the same truths and this style of research provides more comprehensive answers from accessing the data than would be the case with a solely quantitative or qualitative study. For example, qualitative data can explain quantitative results: quantitative work might show dieticians have greater concern than health visitors over nutrient intake in BLW infants, while qualitative research elucidates why.

Using several research methods together increases the transferability and generalisability of findings (page ninety eight in chapter four regarding trustworthiness) by increasing the depth and breadth of the research (Morgan, 2007), and in addition this allows triangulation or verification of results which improves credibility (Creswell, 2014), in this situation with the quantitative studies supporting or challenging the concerns expressed in study one.

In practical terms this means that mixed methods provide more data about a topic because researchers aren't restricted to one method, which gives them a wider view of the truth by answering questions that can't be explained by one method. Other practical benefits include the possibility of multiple avenues for publishing by researchers, and acquiring a wider skillset for students who train with mixed methods researchers (Creswell and Plano Clark, 2018)

Challenges

As is the case in any research incorporating qualitative research, these methods introduce a degree of subjectivity to the work because they rely on the researcher's interpretation and an individual will always have a degree of bias about the nature of the responses and their subjects, however unconscious and in spite of how objectively the original study is planned (Sandelowski, 2010). In large part, because of this inherent nature of qualitative research, mixed methods themselves may be seen as less rigorous and worthy than simple quantitative research, although this is changing (Harrison, Reilly, & Creswell, 2020).

Another challenge rooted in the qualitative aspect of mixed methods research is reaching data saturation, that is, conducting enough interviews or research to capture all novel points of interest brought up by participants (Creswell and Plano Clark, 2018; Guest, 2006). Prior to Guest's work on the theory of saturation there was little agreement on the number of interviews or data points deemed acceptable for qualitative research sample sizes (Guest, 2006), and although Guest posits that 12 interviews may be enough to reach saturation in a relative homogenous purposive sample, he concedes that a more heterogeneous sample may require more. Given that this sample included subjects from varied careers and the exploratory nature of this work, a larger sample was deemed appropriate and 68 surveys from differing professions were included in the final analysis.

Specific to mixed methods research, the researcher is required to understand and be familiar with methods from both types of research, and acquiring these skills may increase time and resource limitations for the researcher. Concepts from different methods such as reliability, validity, bias and the use of software packages used in quantitative research need to be married with qualitative skills such as forming exploratory questions, understanding semi-structured interviews techniques, coding text and familiarity with terms like credibility and trustworthiness, which is an extra pressure (Creswell and Plano Clark, 2018).

In addition, the amount of data generated can mean that the time spent on data collection and analysis is greater in mixed methods work (Halcomb, 2019). Mixed methods research within the limits of a PhD candidacy may also be problematic due to the time taken to complete research a sequential model, such as that used for this thesis (Halcomb and Andrew, 2009). Indeed, the data-collection for the different studies in this project took six years in total, which would stretch the resources of many researchers working independently.

Allied to the generation of large volumes of data, mixed methods research can be challenging for researchers to analyse and report findings in a way that links the two (or more) research projects (Halcomb, 2019). In this instance, the findings of the first study exploring professionals' views of Baby-led weaning were widely referenced in the results and discussions of the later intake studies and the implications of the quantitative studies were directly tied to the concerns of the professionals in study one and the impact on their practice.

Rationale for choosing a mixed methods design

In this instance, a pragmatic, mixed methods approach was chosen due to the interconnected nature of the research questions being posed, which focused not only on the intake of infants using baby-led weaning, but how the results of these enquiries corroborated or challenged the views of professionals in this area and their impact on how they might advise parents in the light of these findings. The use of quantitative research to corroborate or validate the results of qualitative work is one of the strengths of mixed methods (Creswell and Plano Clark, 2018) and one reason why it was a suitable approach for this project.

Given the wide-ranging benefits outlined above, a pragmatic approach was deemed to give the best insight into the topic of baby-led weaning in the UK, and a staged or sequential approach was used, (Creswell and Hirose, 2019), with the results presented in steps starting with a qualitative study surveying the opinions of health and child care providers. This study set the scene for several quantitative studies which addressed some of the concerns raised in the first study. This type of enquiry provided a deeper understanding of how baby-led weaning is being viewed and used in the UK than either method could provide alone. Indeed, mixed methods research is ideally suited for use in nutrition and dietetics research (Zoellner and Harris, 2017), as the act of eating, while providing nutrients and energy that can be quantified, is fundamentally experiential, complex and multifactorial in its drivers.

Although the primary research question revolved around the intake and eating behaviour of infants weaned using the baby-led approach, there was also a desire to explore the question of what health and child care professionals thought about baby-led weaning as a complementary feeding method, particularly relating to their experience, and whether these opinions were justified. This required both quantitative data (such as the levels of key nutrients being consumed by infants weaned with different styles), and qualitative data from in-depth surveys of professionals' opinions on baby-led weaning, which clarified that the intake of BLW infants was also a point of concern and interest for those surveyed.

Thus a pragmatic mixed methods approach was chosen for this thesis as this design focuses on answering the specific research questions stated earlier in the chapter regarding whether BLW is a safe and sufficient method for introducing solids, as well as the consequences and social implications of the research (Creswell and Plano Clark, 2018), reflected by views and opinions of health and child care professionals around BLW and how this may impact on how parents are supported in their decisions.

Introducing the studies

Study One: A qualitative survey of UK health and childcare professionals exploring their opinions, views and experiences of baby-led weaning in practice.

This study was designed to answer research question R1 and responses validated the focus of the subsequent research on infant intake. An internet survey was used to reach health and childcare professionals, from GPs and dieticians to health visitors and nursery workers, using social media and existing professional networks. Questions were designed to explore perceptions of baby-led weaning, its potential benefits to infants and their families, possible disadvantages and the existing knowledge base around the topic. This type of research had been undertaken in other countries but not in the UK, where BLW has been growing in popularity over the last decade (Brown et al., 2017; Utami and Wanda, 2019)

While demographic and closed questions were analysed quantitatively, a simple qualitative, descriptive approach was used for examining the open-ended responses to the survey questions, with the aim of producing results that were "a comprehensive summary of events in the everyday terms of those events" (Sandelowski, 2000). The simple qualitative approach was chosen as it differentiates itself from other forms of qualitative research in that it can render the facts of the investigation with minimal interpretation on the part of the investigator, thus the researcher stays closer to the data, without delving deeper for additional meaning. This is a way of reducing possible researcher bias, which is one of the criticisms levelled at qualitative research (Bryman, 2003). A descriptive approach suited the aims of this study because the questions used in the survey identified practical experiences and simple evaluations rather than deeper emotional events.

The simple descriptive qualitative approach is also suited to studies based on minimally to moderately structured, open-ended interviews, such as the one used in this study, and data analysis based on qualitative content analysis by summarising the information reported in the data (Sandelowski, 2000).

Within this, a thematic analysis was undertaken, identifying key themes and trends in the data using a coding process described in chapter four. This was followed by a content analysis on the themes that arose, facilitated by a conversion analysis or quantising of the themes arising from the qualitative data, with the aim of identifying the most common themes and distribution of themes within the sample (Patton, 2002; Zoellner and Harris, 2017). This was considered a suitable approach for the data as it was useful to understand the frequency of any benefits, concerns and experiences raised, and comparing this between professional types.

Study Two: A survey of dietary patterns and eating behaviour in baby-led and traditionally weaned infants aged 6-12 months

This study was aimed at answering research questions R2, R4 and R5, but like each of the other quantitative studies, also helped investigate some of the beliefs around BLW highlighted by the professionals in study one. It was a quantitative internet-based survey, aimed at parents of infants 6-12 months, who had started the weaning process. Parents answered questions about their infants' weaning journey, eating behaviours and intake in the form of validated tools such as the Child Eating Behaviour Questionnaire (Wardle, Guthrie, et al., 2001) and a food frequency questionnaire adapted from one used in this age group in prior research (Marriott et al., 2008). Analyses were conducted comparing three weaning styles over three age groups. This survey also contained a 24 hour recall, which was analysed separately and reported in study three.

Study Three: Using a twenty-four-hour recall to explore differences in intake between weaning groups

The data collection for this study was carried out at the same time as study two, as the 24 hour recall was included as part of the internet survey, but was analysed separately, in part due to lower participation in this section of the survey. This study was aimed at answering research questions R4 and R5, but also was able to provide data that could build on that generated by previous studies. Parents were asked to list everything their infant had consumed in the previous 24 hours, including any breast milk or formula, and numbers of portions were calculated for eight food groups, iron-containing foods and milk feeds. Number of portions in the 24 hour period were then compared between weaning styles and age groups.

Study Four: A three day weighed food record comparing intakes of infants aged 6-12 months using baby-led or traditional weaning

This study was also aimed at answering research questions R3, R4 and R5, but recruitment and data collection took place independently, following studies two and three. As before, recruitment took place primarily via social media sites. This was the final and most intense design of the three intake studies and as this proved more burdensome for participants, recruitment was limited to 71 parents. Three days of weighed intake information was analysed using dietary analysis software and compared between two weaning groups and two age groups.

Benefits and challenges of specific methods used within the studies

The four studies presented in this thesis shared a number of specific research challenges and methodological decisions that must be made.

1. ***How to define the concept of baby-led weaning.***

Although the term was first coined in the early 2000s and gained popularity in the following decades (Rapley and Murkett, 2008; Rapley, 2018), there is no single definition of baby-led weaning used in the literature (Brown et al., 2017; Utami and Wanda, 2019). Instead, there are several underlying principles associated with baby-led weaning and often used when researchers and others attempt definitions for use in their work. The fundamental principles that differentiate BLW from what might be termed traditional spoon feeding, include an infant picking up and feeding themselves whole, graspable foods from the age of around six months, choosing what to eat and how much from the foods offered by their parent or caregiver, rather than the child being spoon-fed soft purees and infant rice by an adult (Brown et al., 2017). Some researchers have also approached the definition of BLW by looking at adherence by parents i.e. using minimal spoon feeding and puree use, where typically using less than 10% spoon feeding and purees is associated with adhering to BLW (Brown and Lee, 2011a, 2011b; Brown and Lee, 2015).

In this research, two slightly different definition were used. One was used for the first study involving health and child care professionals but was modified slightly for use in the subsequent studies with parents of infants aged 6-12 months, as it was deemed to be fuller, including more behaviours associated with BLW (e.g. infants using a spoon themselves), which might have helped parents clarify if they were using the method, particularly as parents were asked if they were following BLW "strictly", "loosely" or not at all. This division of BLW practice into strict and loose was added because some parents in prior research stated they were doing a mix of methods (Cameron et al., 2012a; D'Andrea et al., 2016), meaning they were using some spoon feeding alongside offering finger foods. However, there had been no investigation into whether this weaning pattern was distinct from the strict definition of BLW (<10% spoon feeding and purees) used in previous work.

Study One:
"Baby led weaning (BLW) is defined as a baby being offered finger food or food in its whole form (not pureed or mashed) and the baby self-feeding rather than being fed by a parent or caregiver".

Studies two, three and four:
"BLW is the process of placing foods in front of your baby and letting them feed themselves – picking the food up themselves and putting it in their mouths unassisted, rather than being spoon-fed by a parent. This could involve them using a spoon themselves. Baby-led weaning tends to involve offering the baby family foods rather than offering pureed foods".

Self-identification of weaning method has been used in previous research (Brown and Lee, 2012; Cameron et al., 2015; Rowan and Harris, 2012; Townsend and Pitchford, 2012) but parents in the studies making up this thesis were also asked how often their child was spoon fed or self-fed and how often purees or whole foods were given using a seven point Likert scale as a method of verifying their weaning behaviour and cross-checking that with the self-selected group. In this way the researcher could see if any mistakes had been made in weaning group selection and any discrepancies were followed up, minimising potential respondent error.

As discussed, previous research had included definitions of baby-led weaning as using purees and spoon feeding by an adult less than 10% of the time to allow for the realistic and occasional use of spoon/puree feeding for convenience. This may have been a logical choice before the term "baby-led weaning" became commonplace as it focussed attention on weaning behaviour rather than a name (which may have been unfamiliar to some parents), but for the purposes of these studies, a description of the behaviours associated with baby-led weaning, parental assent and questions to verify weaning behaviours (which also allowed three distinct weaning styles to be identified) was deemed appropriate. This method of self-definition used in studies two and three has since been replicated and referenced by other researchers (Pearce and Langley-Evans, 2021).

One of the largest investigations into baby-led weaning has emerged from the Baby-Led Introduction to SolidS (BLISS) research group in New Zealand. BLISS used a trial approach, randomising pregnant women into two weaning groups: a modified BLW approach (BLISS) group which advised parents to offer high energy and iron-containing foods daily as well as educating on suitable foods for a BLW approach, and a control group which received standard advice on introducing solids (Taylor et al., 2017). Adherence was defined as infants feeding themselves most or all of their food in the previous week, however, BLISS infants only self-fed 40% of their food at 7 months of age (Williams Erickson et al., 2018) and in a doctoral study of adherence in the trial it was found that at 7 months 64% of the BLISS group were adherent to BLW principles, as were 11% of the usual care group which suggests a degree of cross-over and non-adherence between participants (Williams Erickson, 2015). Self-selection and verification of weaning style as outlined in these studies avoids the impact of effects being incorrectly attributed to particular weaning styles.

2. *Using the internet to recruit a wide sample of participants*

Throughout this thesis, recruitment for the studies took place primarily online, using professional email lists and social media sites to gather participants using purposive sampling. This strategy was chosen because of its convenience and ability to reach a variety of respondents over the whole UK. However, this type of sampling, which shares characteristics with snowball sampling, has consequences for the sample produced, which can be seen as a limitation of the studies.

In terms of benefits, online recruitment allows wider distribution of the research. Baby-led weaning is not formally recognised as a method of introducing solid food by the Department of Health and therefore estimating how many parents are following the method or who may be living in any one area is a challenge. Therefore a wider recruitment net was needed to ensure inclusion of those in particular following a strict baby-led approach. Online recruitment allowed for this, enabling participation from across the UK, and greater participation than if the researcher had focused on an area close to home. Respondents to the qualitative study were located across the country including for example south Wales, Bristol, Newcastle, Reading, Glasgow, London, Ipswich, Southampton and Walsall, allowed a range of professional experiences of BLW to be captured, while the geographic range of parents recruited for the quantitative studies was even wider, allowing access to parents following a BLW approach from across the country.

However, there are limitations with online recruitment. Two potential issues with the method are under-coverage and self-selection bias (Bethlehem, 2010). The former refers to the inability to access those in the target sample without internet access, although in this situation, the target sample of health and childcare professionals and parents of young babies would likely have internet access at work and according to the Office for National Statistics, 86% of UK adults used the internet at the time of the survey (ONS, 2015). Self-selection bias occurs when participants have internet access, visit a website or receive an email or social media notification, and decide to participate in the survey, which means the researcher is not actively in control of the selection process (Bethlehem, 2010). This can be problematic because if a sample is self-selected, the rules of probability sampling cannot be used to create unbiased estimates, potentially reducing the generalisability of the results. In spite of these limitations this method was chosen for recruitment because of its ease of use and the challenges to recruitment particularly for the three day diet diary, within the confines of a PhD candidacy.

3. *Using online surveys to collect data*

Online research is growing in popularity due to its convenience for both researchers and subjects (Ball, 2019; Callegaro, Manfreda, & Vehovar, 2015) but like internet-based recruitment, it has its challenges.

The benefits of online surveys include speed of implementation and return of data, geographical and demographic reach, ease of use, low cost, flexibility and automation of response capture (Ball, 2019). As stated, internet surveys are convenient for participants, which can increase retention and response rate. In this instance, the online format allowed respondents to complete the study at a time of their choosing, with easy access from a computer or smart phone, which was critical for health professionals who are regularly away from their desk during the working day and parents who are working or have childcare commitments. Automation of data capture and responses being entered by the participant themselves cuts down on data entry errors (Callegaro et al., 2015). In this scenario, it was also a cost effective and efficient way to collect data during a PhD thesis, and given this study was designed as a preliminary study in a sequential format (as opposed to a central study), convenience was an important factor.

Importantly, an online survey also enabled health professionals to have greater anonymity when completing their questionnaire, perhaps encouraging them to share their experiences and perceptions more honestly. Given that BLW is not supported by the UK Department of Health, face to face interviews may have caused hesitancy to give opinions or experiences that differed from current guidelines, also referred to as "social desirability bias" (Ball, 2019; Callegaro et al., 2015). This may lead to more honest responses but may also lead to increased numbers of incomplete surveys, known as measurement and non-response errors respectively (Bethlehem, 2010). In this case, only 5 of 73 total responses (7%) were designated as incomplete and thus discarded, and the majority of responses were relatively full.

Internet surveys are not without limitations. For example, respondents needing clarification do not have access to a researcher, which may result in measurement errors, as well as respondents not being motivated to provide all required answers if no-one is present to prompt them. Other challenges include non-response in the desired target sample, which may potentially lead to a biased sample (Bethlehem, 2010). Participants may also be multi-tasking or distracted when completing the survey, possibly introducing errors, but in spite of these limitations, this type of survey has been widely used in healthcare research due to ease of administration and wide-reach for data collection in the community alongside the potential for in depth, detailed responses which enhance knowledge about complex issues (Ball, 2019). Further limitations and benefits of this method of data collection are considered in the general discussion.

Research motivation and reflexivity

The purpose of research is to add to the body of humanity's knowledge about the world, but for those working in the field of health and social sciences, it has been suggested that research should seek to provide practical solutions to issues and improve peoples' lives in some way, rather than simply adding to knowledge (Bryman, 2016). Certainly, the promise of being able to add practically to the lives of parents and those who advise them, was one of the reasons I decided to follow this course of research.

In addition, the training, background and personal values of a researcher may influence their research questions, area of expertise and the methods used (Bryman, 2016), and this was indeed the case for my personal interest in researching baby-led weaning. However, although undoubtedly helpful in designing research and talking about their particular topic, personal experience and values can bring bias into research, particularly in the qualitative space where the researcher is often responsible for interpreting the responses of their participants. This potential inclusion of personal bias in qualitative research has opened the method up to criticism, yet for many the researcher-led interpretation inherent in qualitative research is less of an issue than ensuring trustworthiness and rigor, and in fact the values of the researcher should not be entirely ignored. (Galdas, 2017; Mays and Pope, 1995; Tashakkori and Teddlie, 2009),

Although care should be taken to reduce the likelihood of methodological biases such as sample bias, the researcher can mitigate the effect of personal or value biases in their work by being reflective and honest about the part played by their personal experiences and beliefs, which shows awareness that objectivity is imperfect (Bryman, 2003).

My personal motivation for researching the topic of baby-led weaning stemmed from using this method of introducing solids with my daughter at a time when there was little information available to parents and no peer-reviewed research published. I had come across the method in an online parenting forum and found some articles by Gill Rapley, a British health visitor who had coined the phrase "Baby-led weaning" while investigating infant self-feeding as part of her MSc research. At the time I was in the middle of my MSc in Nutrition and the possibility that BLW might aid in self-regulation of appetite was fascinating, particularly as I had been encouraged to "clean my plate" and ignore my appetite as a child, which had proved a difficult habit to break. My own, largely positive, experiences of introducing solids to my child therefore played a part in directing my initial research into baby-led weaning for my MSc thesis. Although I was unable to carry out research on infants due to institutional restrictions, I looked at the diets of parents using BLW with their infants, and after graduating, my research was published.

I had found BLW worked well for our family: it was convenient, tied-in with some of the theories of eating behaviour that I had learnt during my studies such as Ellyn Satter's Division of Responsibility (Satter, 2000) and my daughter was able to self-feed from the start, but talking to other parents subsequently made me aware that while some had an equally positive experience, many others were put off due to anxiety about choking, worry about wasted food and dislike of ceding control of the feeding process to their infant: feeling that they wouldn't eat "enough" or would eat the "wrong" things. This gave me a different perspective on BLW and demonstrated that it was unsuitable for some families.

When the opportunity to conduct a PhD thesis presented itself, I was more open-minded about the pros and cons of BLW having talked to parents and health professionals as well as reflecting on my own experiences over the years. It was apparent that the weaning period could be both enjoyable and a source of stress and worry. For instance, some supporters of baby-led weaning suggested that it reduced fussiness in later childhood but my own experience with a very fussy child made me realise that BLW was not a panacea for childhood eating issues, while other parents in online forums declared that "before one, food is just for fun", no doubt in an effort to assuage the anxiety of parents fearful that their infant was not eating sufficient quantities. However, as a nutritionist I knew that complementary food should be introduced at around six months of age to supply nutrients needed for growth and development (WHO, 2009). It was clear that there was a need for more evidence around baby-led weaning as the method grew in popularity and although research was being published concerning the experiences of mothers using the method and eating behaviours of their infants, little was published in the UK to demonstrate what these babies were eating and whether this was sufficient to support good health.

Thus, my experience of and curiosity about baby-led weaning led me to continue my research into the phenomenon, with a desire to understand more about its use in this country and how parents could be supported with evidence-based information if they chose to use BLW with their children. Although my experience had been largely positive, I was able to bring some realism about the method into my work, as I was aware of its imperfections and the issues that can be caused when beliefs, including those on the "right way" to feed a child, become too rigid.

Chapter 4: Examining the attitudes and experiences of UK health and childcare professionals towards baby-led weaning as a method of introducing complementary foods to infants

Introduction

As highlighted in chapter two, baby-led weaning, the self-feeding of solid foods by an infant, has grown in popularity over the last fifteen years. Although no official data shows what proportion of new parents choose this approach, BLW has become increasingly visible over the last decade, as shown by the large online communities dedicated to helping parents use the method. However, despite its popularity, the method is not supported by the UK Department of Health as a recommended method of introducing solid foods to infants, although the use of finger foods from six months of age alongside purees is mentioned in the guidance (NHS, 2015). Although the SACN report in 2018 recognised the method, it concluded that further data was needed as to its efficacy and safety.

To move forward with ensuring that parents receive the support they need, a greater evidence base needs to be collated surrounding use and impact of the baby-led method. To start, a better picture is needed to understand the perceptions and concerns of those supporting parents who may be following baby led weaning – health professionals. Although research has examined health professional beliefs around the approach in other countries, no research has examined this topic in a UK setting. Given recommendations and guidance around introducing solid foods can differ in different countries, it will be useful to understand the experiences of those specifically working in the UK.

Research that has explored health professionals perceptions of baby-led weaning in other countries has identified a variety of views. For example, research in New Zealand explored the attitudes of health professionals towards baby-led weaning, including identifying concerns that they hold in relation to the approach (Cameron et al., 2012a; Caroli et al., 2012). In 2012 Cameron et al explored health professionals' attitudes to baby-led weaning using in depth interviews. They found that almost half of all the respondents had heard of the approach. When details about the method were provided, all participants could see benefits for the family and child such as greater exposure to a variety of foods, joining in family meals and self-regulation of appetite. However, common concerns were raised around the possibility of choking, failure to thrive, poor food choices and reduced iron intake. They also highlighted possible issues for some parents, such as mess and food waste.

Likewise, the attitudes of Canadian HCPs to BLW were also examined in a qualitative study of sixty-five mothers and thirty-three professionals. The greatest concerns of HCPs were that BLW would increase parental anxiety, increase the risk of choking and lead to inadequate iron and energy intake (D'Andrea et al., 2016). However, they also highlighted possible benefits such as fine and motor skill development, increasing family mealtimes and aiding with satiety regulation. The findings of such a study would enable further research to be conducted to explore whether any concerns expressed are valid and if evidence is found to support or negate these concerns, to consider the best way policy makers and professionals could work together to support new parents who are choosing the approach e.g. understanding the training needs of professionals working with parents or pathways to supporting parents who use the method.

This first study therefore sought to answer the first broad research question of 'What are health professionals concerns about dietary intake and weaning style?' within a UK context. The results of this study will then inform the direction of the remainder of the thesis. Specifically, the aims of this first study were to use a qualitative survey to:

1. Investigate whether health professionals in the UK are encountering parents who follow a BLW method
2. Examine what information and support parents ask for, and the advice professionals give in relation to BLW
3. Understand what professionals perceive as the benefits and risks of a BLW approach.
4. Explore whether professionals have any concerns regarding the BLW approach

Methodology

Design

This study used an online survey consisting of both open and closed questions to explore perceptions of health professionals as to the use and impact of baby-led weaning. An open-ended survey was chosen over face-to-face interviews to allow participants greater flexibility in completing the research at a time convenient to them, whereas arranging face to face interviews would be challenging and place time and convenience burdens on participants. It also allowed for a larger sample to participate, reducing the time needed for each participant to complete the study. This can enhance participant diversity (Allen, 2017). For further reflection on this approach please refer to the methodology chapter.

Closed questions were used to ask for demographic and employment information and knowledge around BLW, while open-ended questions were used to allow respondents to elaborate and to gain deeper insight into their views. Open-ended questions also have the benefit of corroborating the results of closed ended questions, validating or highlighting issues with the question (O'Cathain and Thomas, 2004). In this instance, respondents were asked whether they had experienced BLW in their professional capacity (closed question) and then an open ended question asked: "if yes, how did you feel about it?".

Although useful, open ended surveys have limitations such as the burden of writing responses, which may be time-consuming and lack of access to a researcher for clarification. A fuller discussion of their benefits and challenges is found in the methodology chapter.

Additionally, the decision was made to use online data collection, which is becoming increasingly common in healthcare science research (Ball, 2019), but as detailed in the methodology chapter there are a number of limitations to online research and these are recognised as applying to this study. However there were particular benefits to using this method of data collection such as gathering participation from across the UK, allowing a range of experiences to be captured at a time convenient for respondents, as well as allowing them to maintain anonymity. In part because of these benefits, this type of survey has been widely used in healthcare research as an easy to administer and wide-reaching tool for data collection in the community with the possibility for in depth, detailed responses.

Participants

The survey was initially aimed at healthcare professionals based in the UK who had contact with parents with an infant under the age of one and were involved in supporting infant nutrition. This included but was not limited to health visitors, dieticians, general practitioners and specialists. These are the individuals that parents might typically seek advice from when introducing solids to their infant (e.g. health professionals) or encounter if difficulties arise (e.g. a dietician or GP). Although the survey advert stated that it was looking for the opinions of health care practitioners, numerous child care workers completed the survey. The responses were not limited to traditional health care professions as there was an option to state "other" profession, and it was open to those who worked closely with infants being introduced to solid foods. Therefore in the event, the survey was responded to by lactation specialists, lay-support workers and child-care workers in addition to healthcare and nutrition specialists. It was decided to create two specific categories (lay support and child care) and include these professionals in the data analysis as they would potentially be involved with, or affect, the weaning process as it evolved (e.g. nursery practitioners caring for an infant being attended a nursey day care setting who were following a baby-led approach at home and / or in the nursery setting).

In total twenty childcare workers and lay supporters such as breast feeding specialists responded to the survey. It was decided that including these responses gave useful perspectives on how baby-led weaning was seen in a different section of professionals working with infants and their parents. With an estimated 1.4 million children aged 0-4 attending childcare settings before the Covid-19 pandemic (Blanden et al., 2020), the importance of those working in the sector is clear.

The importance of feeding in early years settings was acknowledged by the implementation of the voluntary government guidelines for infants and toddlers in child care facilities in 2012, yet no mention of baby-led weaning has been made in the current guidelines updated in 2017 (AFC, 2017; Mucavele, Wall, & Whiting, 2020). As far as the researcher is aware, there is no published work on the views of childcare workers on baby-led weaning, and thus this work provides valuable insight on the views of an important group of professionals working with infants and involved in their feeding in a daily basis.

Approval for this study was granted by the Swansea University Department of Psychology Research Ethics Committee. All participants gave informed consent prior to inclusion in the study. Ethical considerations were made with respect to the principles for research on human subjects outlined in the World Medical Association Declaration of Helsinki. As such, all subjects were provided with information about the study and were informed regarding their consent and the anonymity of their data and responses.

Measures

Participants completed an online questionnaire that incorporated both closed (tick box) and open-ended questions (see table one).

The questionnaire included:

1. Background information: occupation, years of experience and work location in the form of a postcode
2. The familiarity of UK professionals with the principles of BLW. Participants were given a definition of baby-led weaning and asked whether they were familiar with the concept, with the option of responding yes, no or not sure.
   "Baby led weaning (BLW) is defined as a baby being offered finger food or food in its whole form (not pureed or mashed) and the baby self-feeding rather than being fed by a parent or caregiver".
3. Whether they had come into contact with parents who followed the method, with the option of responding yes, no or not sure.

Open-ended questions then explored their attitudes to and experience of baby-led weaning in their professional life (see appendix 1). Questions examined personal knowledge, confidence in, and perceptions of BLW use by parents, with whom the professionals may have contact; whether BLW was used successfully, or not, as well as perceived advantages, disadvantages and any personal concerns about the method. Following this, the participants were specifically asked about their views on the potential impact of BLW on a child's nutrient and energy intake. This was placed after the initial questions asking for advantages and disadvantages to explore whether participants naturally raised issues regarding nutrient and energy intake, rather than with the leading question alone. There was also a final box at the end for further comments. Examples of open-ended questions are shown in table one.

Table 1: Open-ended questions in Study One: Professionals' Survey

- What advice are you able to offer if a parent asks for guidance on using BLW with their baby?
- What has been your professional experience of seeing how BLW has worked (or otherwise) with parents and their children?
- What do you see as the advantages of a Baby led approach to solid food introduction?
- What do you see as the disadvantages of a Baby led approach to solid food introduction?
- Do you have any concerns about the Baby led approach?
- What is your opinion of the effects of using BLW on a child's nutrient and energy intake?
- Do you have any other comments?

Questions were based on themes raised in previous research examining health professionals' attitudes and experiences towards BLW in New Zealand (Cameron et al., 2012a) and work in the UK with mothers that raised the issue of professional concerns towards BLW (Brown and Lee, 2013). Questions were designed to examine both perceived benefits and concerns and were deliberately non-leading and non-specific to allow for new benefits and concerns to emerge (e.g. "Do you have any concerns about the baby-led approach?" rather than "Are you concerned about choking?"). All questions were designed with open-ended text box answers with no character limit. This meant that the respondent could write as much or as little as they wished in each box. Participants could leave questions blank if they wished, with the exception of consent items.

Procedure

Participants were recruited through local health and childcare professional networks and social media. Participants were encouraged to share the study information with their own networks. This enabled participants from across the UK to be invited to take part in the survey, giving a wider potential range of attitudes compared to a local sample.

If participants wished to take part they clicked on a link, which took them to the survey hosted online by Survey Monkey. The survey had a full information sheet describing the study aims and methods in detail. Informed consent questions were required to be completed for the survey questions to load. Contact information was given for both the researcher and supervisor if further questions were raised. A debrief loaded at the end of the questionnaire. Participants could also request a paper copy of the questions that contained the same information and consent forms and details on how to return to the researcher anonymously. Participants gave details of UK postcode in which their work was based to ensure UK participation.

For the social media adverts, study adverts were placed on social media e.g. Facebook and Twitter. Again information was given about the study, with an invite to click on the Surveymonkey link if interested in participating, taking them to the information sheet which gave fuller details of the study. Although tweets were limited to 140 characters, the link provided full details. This approach was a useful technique for reaching a wide range of health and childcare professionals. The researcher and particularly the supervisor have significant professional contacts on Twitter, specifically around dietetics and health visiting, meaning that this method was an efficient way of sharing details of the study. It was also considered a non-invasive way of advertising the study, as adverts were indirect and non-personal.

Specific follower groups that the researcher and supervisor follow on Twitter were targeted to enhance recruitment. For example, a popular hashtag on Twitter is that of 'WeHealthVisitors' that has around 700 followers. Tweets were made adding this hashtag and asking for the study to be retweeted. This meant that not only Twitter followers saw the tweet but that those following the hashtag were also notified of the study. They could then follow the link in the tweet to Survey Monkey where they would find more details of the questionnaire. Participants also acted as gatekeepers, distributing details of the study to their networks both through word of mouth and themselves using social media (e.g. 'retweeting'). The benefit and limitations of using social media for recruitment in this way are considered in the discussion and in chapter three.

Data Analysis

Quantitative data (closed items) were analysed using SPSS v.19 (IBM). Descriptive tests were used to examine aspects such as frequency of closed item responses, number of participants from each professional group and mean years of experience. Inferential statistics were used to examine frequency of themes raised by participants and between participant groups in the content analysis. Incomplete responses were discarded, totalling 5 of 73 surveys (7%) and the majority of responses were relatively full.

Open-ended responses to the survey were analysed using a simple qualitative descriptive approach as described in chapter three which describes the tools and methodologies used in the course of this thesis.

A quantifying of themes (known as conversion analysis) was undertaken as it was considered a suitable approach for the data, as it was useful to understand the frequency of any benefits, concerns and experiences raised. For example, if choking was raised as a concern, how common was that concern. Given that the data could be used to support further research or development of guidelines or training, it was important to understand the most prevalent themes e.g. if choking was raised by 50% of the participants it would be a more pertinent issue than if it was raised by 10% of participants. It is also a useful technique to be able to quantitatively compare across professional groups as this may inform specific concerns and training needs e.g. do health visitors have greater choking concerns than dieticians?

Three steps were therefore taken in analysing the data: downloading the data, coding the data into themes and a quantitative count of themes.

Coding

No participant requested a paper copy of the questionnaire; all questionnaires were completed electronically using the Surveymonkey link. All responses were therefore downloaded directly from Survey Monkey into Excel. This was a benefit of collecting the open-ended data in a written format, as no transcription was needed. Downloading responses into a tabular format also meant that responses could be examined across questions for each participant (reading horizontally) and responses for each individual question across participants (reading vertically).

Given the anonymous electronic based method of data collection, the potential for participants to start the questionnaire but not finish, or to give very brief data arose. Participants who began completing the questionnaire but stopped after a few questions were deleted from the analysis. The decision was made that participants must respond to 60% of the questions to be included in the data, as used in similar qualitative research (Brown and Davies, 2014). This allowed for participants to skip some questions. However, if participants clearly started the questionnaire but did not finish, for example answering the first questions and leaving the remainder blank, they were excluded from the analysis. This also applied if they did not reach the general open-ended questions relating to benefits and disadvantages. The depth of the responses was also considered in inclusion. The decision was made that if participants wrote very brief answers e.g. less than a few words per response with little meaning, then their response would be discussed between coders and exclusion considered based on depth of content, as word count does not necessarily dictate content response. However, as noted in the results, this situation did not arise.

Initial analysis involved reading through each individual participants' responses. Keywords were identified and labelled for each. For example, the phrase "we will have to have more training on it" was coded as "training", while the word "fantastic" was coded as "positive view". Three levels of codes emerged. Very broad codes, such as health benefits, were considered categories. Within each category, broad themes were identified, which in turn contained smaller sub themes. For example, the subthemes "choking concern" and 'wrong foods" were grouped into the theme "safety concern" which in turn was part of the category "perceived disadvantages". All answers were coded within a category, theme and sub theme.

Initially it was intended to present the resulting themes and subthemes for each individual question, discussing them in a narrative fashion. For example, for the question "What has been your professional experience of seeing how BLW has worked (or otherwise) with parents and their children?". However, when coding was completed, it became apparent that examining the themes and subthemes of the scripts as a whole, rather than analysing each question individually, would improve the resulting qualitative data. Therefore, when the scripts were reanalysed, subthemes were identified across different questions. For example "mess" may have been identified in Q2 (What has been your professional experience of seeing how BLW has worked (or otherwise) with parents and their children?) and Q5 (What do you see as the disadvantages of a Baby Led approach to solid food introduction?).

Once the initial coding had been conducted, the scripts were then read for confirmation by a second coder. Agreement was reached in over 90% of the cases. Data saturation principles were reached for the key themes (Guest, 2006) and overall the sample size exceeded minimums for qualitative data (Bernard, Wutich, & Ryan, 2016; Creswell, 1998).

Content analysis

In addition to identifying the themes to undertake a qualitative analysis, a content analysis was undertaken to count overall how many times a theme emerged. Each participant was categorised as yes or no for each category, theme and sub-theme. For example, for the sub-theme 'Mess' the number raising this concept and the number who did not was calculated. This allowed for quantitative counts of the number of participants who raised each theme. Further broader counts included how many categories, themes and sub-themes each participant identified. Moreover, identification of categories, themes and sub-themes could be compared for different professional groups, or those with more or less years of experience, raised specific or significantly more issues.
To undertake the professional group analysis, participants were grouped into five main occupational roles:

- Public health
- Lay supporters
- Medical staff
- Childcare
- Nutrition specialists

The role groupings listed above were chosen because they encompassed the job titles and professions given by participants but also because they each have distinct experiences and relationships with the families they encounter. Public health workers, most often health visitors, engage in health promotion and visit many different families during a working week. Lay supporters such as breast feeding counsellors, are not medically trained and therefore may be less familiar with or concerned by potential health issues, whereas medical staff are trained to diagnose illness and notice risks to health. Child care workers may be more likely to be concerned with practicalities of caring for infants and their safety and may not be focused on health concerns, whereas nutrition specialists have specific knowledge around nutrient intake and food preparation which may influence their views.

Simple descriptive statistics were used to analyse counts and chi square used to explore associations between specific themes and occupations. One way ANOVA were used to compare number of themes raised by occupational groups. Pearson's correlations were performed to explore length of time since qualifying and number of themes raised and t tests to explore differences in length since qualifying for those who raised a theme and those who did not (e.g. yes / no to mess). Further discussion and explanation of the qualitative methodologies used in this research is found in chapter three.

A note on trustworthiness in qualitative research

To ensure trust can be placed in the findings of the qualitative aspect of mixed methods research as outlined by Lincoln and Guba (1985), the criteria of credibility, transferability, dependability and confirmability should be met (Lincoln, Guba, & Pilotta, 1985; Nowell, Norris, White, & Moules, 2017).

The *credibility* (akin to internal validity) of a study, or whether information and perceptions of the participants can be recognised and believed by readers, can be improved by using multiple observations, several data analysis techniques (detailed surveys and intake studies to verify or challenge the opinions of the professionals), more than one researcher (known as researcher triangulation) and data collection triangulation through using more than one source (the professionals survey, large internet survey of parents and an in depth three day weighed food diary). In this instance, sixty-eight survey scripts were analysed, data collection involved quantising results and the coding was checked by a second researcher. In this way, the broadest possible picture was planned, within the confines of a PhD candidacy.

Transferability, which equates to the external validity of quantitative research, refers to how generalisable the findings are, which in qualitative research depends on how easily findings can be used for a different set of people, which can be improved by increasing the breadth and depth of data collected, as is the case in mixed methods design. Certainly these findings (the views of health and child-care professionals) might also apply to parents or other non-professionals dealing with children, and thus the data are transferable.

Dependability or reliability relies on auditing, in other words, ensuring the work is logical, traceable and documented (Tobin and Begley, 2004). In this case, when decisions were made to change or reclassify certain themes, they are highlighted above.

Confirmability or objectivity, is achieved when the researcher's findings are closely related to the data. In this instance, not only are quotes given to support each point made, but the themes were quantified to demonstrate the prevalence of view and opinions. It has been suggested that the inherent confirmability of qualitative data coupled with the strength of quantitative data improving the transferability of the findings (Morgan, 2007; Shannon-Baker, 2016).

Although the studies that formed this thesis were separate entities, they were connected by a common thread: the use and effectiveness of baby-led weaning. The context outlined by the subjects of the initial qualitative study themes set the scene for the subsequent quantitative enquiries into the nature of BLWs effects on infant food intake and behaviour.

Results

Sixty-eight respondents were included in the study, after five were excluded for non-completion. The participants had an average of 9.2 years of experience (SD: 9.58) with a range from less than one year to thirty three years. When given the definition of BLW, all but one of the sixty-eight respondents included in the study had heard of baby-led weaning (99%), and 63 (93%) had experienced parents following BLW in their professional capacity. The number of participants in each professional role group is shown in table two.

Table 2: Number of participants and percentage in each professional group

Professional group	N	%
Public health (including Health Visitors)	36	53
Lay supporters	13	19
Childcare professionals	7	10
Medical staff	6	9
Nutrition specialists	6	9

Training and confidence

Participants were asked a series of questions around training and confidence in supporting BLW. Table three highlights responses between different professional groups. Overall, 21 participants (31%) had received training, 44 (65%) had received no training and 3 (4%) were not sure.

Table 3: Training and confidence of different professional groups

Professional group	Received training		Want more training		Feel confident	
	N	%	N	%	N	%
Public health	13	36.0	27	75.0	22	61.1
Lay supporters	5	38.5	5	38.5	10	76.9
Childcare professionals	2	28.6	5	71.4	4	57.1
Medical staff	0	0.0	0	0.0	2	33.3
Nutrition specialists	1	16.7	4	66.7	4	66.7
Total	**21**	**30.9**	**41**	**60.3**	**42**	**61.8**

As table three shows, confidence levels appear higher than training levels, suggesting participants are gaining confidence from either their experience or own research. Conversely, participants were potentially overly confident in relation to their knowledge, perhaps not knowing what they do not know. Notably, the professionals most likely to see parents with concerns over weaning, i.e. medical specialists and public health workers also had low levels of training on BLW, with no medics and 36% of public health workers respectively. Although there were no significant associations between having received training and professional group, none of the medical profession group had received training compared to higher percentages seen in the other groups. When asked directly whether they would like more information and training on BLW and how it can be implemented, 41 participants (60%) said yes, 16 (24%) said no, with 11 (16%) were not sure. Finally, in terms of confidence in knowledge around BLW, 15 respondents (22%) replied that they did not feel confident, 11 (16%) were not sure and 42 (62%) stated that they were confident in their knowledge. Again no significant association was found between professional group and desire for more training.

Thematic analysis

Thematic analysis identified three main overall categories relating to their beliefs about BLW: positive, negative and conditional, the latter being used to convey a degree of ambivalent feeling around baby-led weaning. From these categories, five themes of health benefits, practical benefits, practical issues, safety concerns and nutrient intake concerns were derived. From within these themes, a number of sub themes emerged (see table four).

Two additional categories relating to training and advice emerged from analysis of the survey scripts. The latter was directly related to question 8, which asked what advice the respondents were able to give if a parent asked for guidance on BLW, while the theme of "training" (wanting more BLW-specific training or desiring more research and information) emerged from answers to various questions. These categories are discussed in section on training in the results as they were analysed separately.

These responses were individually coded, giving a further series of themes and sub themes. Respondents discussed the issue of working with baby-led weaning in practice, particularly their advice to parents curious about baby-led weaning and the need for more training and official guidance on implementing BLW.

A content analysis was used to quantify the frequency of benefits and concerns raised. Table four shows a summary of the proportion of participants who identified each category, theme and sub theme.

Table 4: Proportion of participants identifying each theme and sub-theme

Category	N	%	Theme	N	%	Sub-theme	N	%
Positive	63	93	Perceived health benefit	44	65	Self-regulation	26	38
						Motor skills	22	32
						Variety	13	19
						Healthy food	13	19
						Breastfeeding	7	10
			Practical benefits	52	76	Psychological	18	26
						Convenient	10	15
						Family meals	20	29
						Food acceptance	33	49
						Common sense	7	10
Negative	57	84	Practical Issues	29	43	Mess	16	24
						Cost/waste	10	15
						Time-consuming	3	4
						Eating behaviour	6	9
						Prescriptive	5	7
			Safety concerns	39	57	Choking	29	43
						Inappropriate foods	22	32
						Developmental difficulties	10	15
			Nutrient / energy intake concerns	28	41	Poor nutrient intake	14	21
						Poor energy intake	14	21
						Poor weight gain	5	7
Conditional	40	59				Ambivalence	17	25
						Dual approach	16	24
						Parental anxiety	17	25
						Parental attitude	13	19
						Tradition	5	7%

Looking at some of the most common responses it is notable that these are often opposing sides of the same issue. For example 49% of participants raised the positive benefit of food acceptance but 32% discussed inappropriate foods and 21% both poor nutrient and energy intake.

Looking at the overall pattern of responses and how many participants held a positive, negative or ambivalent view on baby-led weaning, the majority of respondents (n = 52, 76%) raised both positive and negative aspects to baby-led weaning. Just 16 (24%) either solely stated advantages or disadvantages to the method, 5 (7%) having solely negative views and 11 (16%) making only positive comments. The categories, themes and sub themes are presented in more detail below:

Category One: Positive beliefs

Participants' positive beliefs were directly examined through questions about perceived advantages of baby-led weaning (e.g. What do you see as the advantages of a Baby Led approach to solid food introduction?) but also emerged through the less direct questions (e.g. If you have experienced BLW how did you feel about it? What is your opinion of the effects of a using BLW on a child's nutrient and energy intake? What has been your professional experience of seeing how BLW has worked (or otherwise) with parents and their children?). Overall 93% of participants expressed positive views, with two main themes emerging: perceived health benefits and practical benefits, which between them contained ten sub themes.

1. Perceived health benefits

Perceiving baby-led weaning to offer health benefits was expressed by 65% of respondents. Most participants listed at least one benefit, with some raising several across different aspects of the approach. The average number of health benefits coded per respondent was 1.19, rising to 1.84 for those with at least one affirmative code, with a range of 1 to 4 out of 5 possible codes. Benefits focussed on the impact of the method on the infant e.g. weight or appetite regulation, or more broadly such as encouraging breastfeeding.

a) Self-regulation of appetite

The most frequently noted perceived benefit was the belief that the method allowed babies to self-regulate their food intake. 38% of all participants cited self-regulation of appetite (eating to satiety) as an advantage of baby-led weaning. The suggestion arose that this was because the infant was allowed to feed at their own pace and there was less pressure from parents for the child to keep eating once they were full. This ability to control the pace and volume of food ingested was also believed to reduce the likelihood of obesity.

> *"Reduction in obesity… self-regulation for children with their diet- knowing when they are full or hungry" (#21, Health visitor)*

> *"More suited to each baby's individual needs as they are able to take things at their own pace. Less chance of baby learning over-eating behaviour" (#60, Breastfeeding counsellor)*

b) Development of motor skills

Another perceived benefit was that the approach supported physical coordination, such as development of language skills and hand-eye coordination. 32% of total respondents cited improved coordination or speech and language development as a benefit of BLW.

> *"Improves hand eye coordination. Infants become highly skilled at feeding themselves. Improves oral motor skills" (#50, Health visitor)*

> *"They are gaining manipulative skills with good hand/eye coordination, using the muscles in the mouth helps with language development" (#28, Health visitor)*

c) Healthy food choices

Being offered healthy food choices was also a perceived benefit of BLW, according to 19% of total respondents. Reasons given for this belief included the child being given family foods leading to healthier eating for the whole family, for example by the parents reducing salt in the whole family's diet, to the infant being given less processed foods because they wouldn't be eating jars or pouches of purees.

> *"It lets the child participate in family meal times and I think the whole family will eat healthier as a result" (#10, Registered Dietician)*

"Babies can be fed anywhere at any time without having the need for preparation of baby jars. You know exactly what is in your own food". (#33, Health visitor)

"Baby can eat what the rest of the family is eating and that probably means they eat far less processed stuff" (#40, Health visitor)

d) Variety of foods

An increase in variety of foods was another possible benefit suggested by 19% of participants , who posited that parents using this method might offer a wider variety of foods and babies themselves may be more open to trying different foods.

"Babies who are weaned via BLW tend to eat a wider variety of food" (#26, Health visitor)

"I think it would work well. Baby gets offered more things that the family are eating so gets more tastes" (#40, Health visitor)

e) Protects and encourages continued breastfeeding

The final perceived health benefit was baby-led weaning's support for breastfeeding and continued milk consumption in the first year of life. Overall 10% of respondents mentioned milk consumption as a benefit or consequence of BLW. The rationale for this could have been that BLW was seen as a continuation of the "on-demand' feeding often associated with breast-feeding or that breast feeding mothers may delay introduction of solids until closer to six months of age, when baby-led weaning is feasible and the age now recommended by the Department of Health ((HSC), 2015).

"It works well for the parents using it. Most of not all are breastfeeding women and BLW fits very well with this. It makes sense to me to follow developmental cues for feeding and self-feeding appears to cause no feeding issues in the well infants and young children using it" (#66, Infant feeding specialist)

"Milk is the most important for of nutrition for babies under 12 months so the volume of food they eat is not as important as offering a child a large variety of tastes and textures so that by the time they are a year old they will eat everything they are offered" (#28, Health visitor)

2. Practical Benefits

The second major theme that arose in respondents' comments was that of the perceived practical benefits of baby-led weaning. This theme contained subthemes coded as emotional, social, family meals, food acceptance and common sense. 52 of 69 respondents (76%) cited at least one practical benefit to BLW. The average number of practical benefits coded per respondent was 1.24, rising to 1.69 for those with at least one affirmative code, with a range of 1 to 3 out of 4 possible codes.

a) Psychological benefits for parents and babies

The emotional benefits highlighted by those surveyed included less stress for parents, and happier, more confident babies. Overall 26% of participants talked about the positive psychological benefits of BLW.

> *"A healthy relationship with food. Autonomy and control of feeding themselves contributing to confidence. Less stress." (#63, Public Health)*

> *"Parents practicing BLW are usually more relaxed & confident- this impacts positively on the baby. Parents who have been practicing demand feeding effectively are more sensitive to babies cues & expressions of need & show a higher degree of sensitivity & understanding of their baby as an individual" (#49, Health visitor)*

b) Convenience

Perceived convenience or social benefits included BLW being cheaper and more convenient, since babies are, in theory, eating the same foods as their parents and there was believed to be less reliance on manufactured and shop-bought baby foods. Overall 15% of respondents cited social benefits such as those outlined below:

> *"Financially beneficial as more likely to use home foods and not ready made manufactured baby products" (#50, Health visitor)*

> *" Sharing meals is quicker, cheaper sociable" (#22, Nursery nurse)*

c) Family meals

Overall 29% of respondents mentioned the ability of the infant to take part in family meals, which was believed to enhance social skills, be more convenient for parents and more cohesive for the family.

> *"It helps baby to explore food, participate in family mealtimes, eat to their appetite. From my experience means family members eat together more frequently" (#49, Health visitor)*

> *"They can participate in family meal times to learn about communication, dialogue, language, non-verbal behaviour and the development of social skills and copy adult eating behaviour" (#68, Infant feeding coordinator)*

d) Food acceptance

Another practical benefit was the subtheme of "food acceptance", which was used to cover codes such as fussiness (or lack thereof), food exploration and acceptance of new tastes and textures. This was the most commonly found subtheme of practical benefits, with 49% of participants naming at least one practical benefit.

> *"The baby can experiment with food textures, consistencies and flavours for him/herself. The baby can have fun while learning about foods. The child is able to eat how much/little that he/she wants" (#25, Health visitor)*

> *"Children learn how to have fun with food and it be a pleasurable experience allowing them to experiment with different flavours, textures and tastes." (#68, Infant feeding coordinator)*

e) Common sense

"Common sense" was the final subtheme within the Practical Benefits theme, with 10% of respondents citing this as a benefit of BLW. Here participants talked about the method simply 'making sense' or being a normal and natural way for infants to eat.

> *"I like the method as it promotes trying new foods and eating new things. It is a very common sense way of eating and feeding babies" (#3, Nutritionist)*

"… it is common sense to me to allow babies to join in mealtimes and eat what you eat. That is the eventual aim overall isn't it so why not start from the beginning?" (#8, Health visitor)

<u>Category two: Negative beliefs</u>

However, all but 11 of the participants (84%) named at least one potential issue with the method (range = 1-6) ranging from practical problems such as mess and cost to perceived issues with nutrient intake. This emerged again both through direct questioning and more open questions, for example: If you have experienced BLW how did you feel about it? What has been your professional experience of seeing how BLW has worked (or otherwise) with parents and their children? What do you see as the disadvantages of a Baby Led approach to solid food introduction? Do you have any concerns about the Baby Led approach? What is your opinion of the effects of a using BLW on a child's nutrient and energy intake?

Eleven sub-themes emerged during the data analysis, which were divided between the themes of practical issues, and safety and nutrient intake concerns.

1. <u>Practical issues</u>

Practical issues were cited by 29 of 68 respondents (43%), with a range of 0-3 concerns out of 5 subthemes and an average of 1.38 per affirmative respondent and 0.58 per overall participant.

a) Mess

The potential for mess when using BLW was the most commonly mentioned practical issue, with 24% of respondents raising this issue, often simply by stating, "mess" or "messy".

"The mess on the floor afterwards!" (#29, Nursery nurse)

"It can be a bit messy but I don't think any more than spoon feeding necessarily." (#64, Breastfeeding counsellor)

b) Cost/waste

Overall 15% of respondents cited cost or excessive waste as a possible issue, suggesting that this could be particularly problematic for low-income families.

"Could cause excess wastage, may not be suitable for families on a low income" (#45, Nutritionist)

"There are also families who cannot afford or are not prepared to spend time and money preparing fresh food for their infant" (#68, Infant feeding coordinator)

c) Time consuming

The potential for BLW to be "time-consuming" was mentioned by 4% of respondents but it was still judged to warrant its own code, as it was in direct contrast to respondents' comments coded as "Social/convenient", cited by 10 (15%) individuals.

"Time element for busy families as baby may take longer to feed." (#38, Health visitor)

"Time consuming and baby may not eat what he needs" (#30, Health visitor)

d) Eating behaviour

Eating behaviour was a sub-theme used when coding comments regarding fussiness and infants' feeding preferences. The subtheme "Eating behaviour" was found in 9% of respondents' surveys and could be contrasted to the subtheme "Food acceptance" (which was highlighted by 33 or 49% of participants).

"I think fussy babies might become more fussy as they can avoid foods they do not like" (#10, Registered Dietician)

"Some babies prefer to drink than eat therefore parents may need to help with feeding." (#33, Health visitor)

e) Prescriptive / divisive

Finally the sub-theme "Prescriptive/divisive" was identified as a practical concern, with 7% of participants believing that baby-led weaning was either too prescriptive in its rules or had overly provocative proponents, which had led to a negative view of BLW.

> *"Seems prescriptive and strange to have such rules. Is this a new fad or just the same old in a different name?" (#5, GP)*

> *"…the rigorous way it is sometimes applied. Some babies choose and want purées and mums can feel they are breaking "BLW rules" by spoon feeding" (#54, Breastfeeding counsellor)*

2. <u>Safety concerns</u>

Three safety concerns were identified: choking, developmental readiness and wrong foods. 39 out of the 68 total respondents (57%) identified at least one safety concern with baby-led weaning, the range being 1-3, with an average of 0.88 concerns for all respondents and 1.6 for those who had at least one concern.

a) Choking

The most commonly cited safety concern was the subtheme "choking", which was a potential issue mentioned by 43% of participants, who discussed concerns over dangerous food choices leading to potential choking incidents and nursery workers unable to adequately monitor all the infants under their care.

> *"It is difficult in a nursery setting. I am concerned about choking as I am not used to giving babies that young those foods. We also need to watch the baby closely as we are worried about choking which is difficult when you have lots of children to watch" (#4, Nursery nurse)*

> *"Choking is my biggest worry and giving the wrong types of food. Just because a baby can pick up a food doesn't meant they should eat it. I mean they could pick up the guinea pig but it's probably best they don't eat that" (#12, Health visitor)*

b) Risk of inappropriate foods being offered

Offering the child or the baby choosing inappropriate foods was the second most commonly mentioned safety issue, with 32% of respondents stating they were concerned with babies eating foods that were high in salt, poor quality or dangerous.

> *"If money is tight then they might get cheap foods. I worry the advice to give them what you eat could be taken the wrong way!" (#8, Health visitor)*

> *"I worry about the wrong thing being given. The wrong foods. Things that have been cooked with a lot of salt or added stuff or things that aren't suitable" (#40, Health visitor)*

c) Developmental difficulties

Finally, developmental readiness was a concern for 15% of participants, with issues such as prematurity, dental development and age at weaning being mentioned as possible barriers to implementing baby-led weaning.

> *"Some babies may struggle initially if not reached certain developmental stages/don't have teeth." (#47, Nutritionist)*

> *"Some infants may have difficulties if they are developmentally delayed in any way - preterm infants for example. A modified form of BLW can then be used where the parents feeds the infant at the same time as the infant has experience handling food." (#67, Breastfeeding counsellor)*

3. <u>Nutrient and energy intake concerns</u>

Intake concerns were divided into subthemes of nutrient intake, weight/failure to thrive and insufficient food. 28 participants (41%) mentioned one of these concerns, with a range of 1-3 concerns and an average of 0.5 concerns for all participants and 1.2 concerns for those stating at least one.

a) Poor Nutrient intake

Nutrient intake was an issue for 21% of participants. Participants worried that infants would avoid foods or not be able to consume sufficient nutrients.

"I would worry that some babies would not be able to feed themselves and would become malnourished" (#12, Health visitor)

"It might work but I am dubious - and concerned in some cases that infants will be allowed to become malnourished in this idea that babies can simply choose what they wish to eat." (#41, GP)

b) Poor energy intake

The possibility of infants consuming inadequate food or energy was mentioned by 21% of participants. As infants were allowed to be in control of volume consumed, some may under eat, or struggle to eat enough to meet their needs.

"Ability of parents to ensure adequate amount of food provided" (#20, Health visitor)

"Worries about how much baby eats, are they eating enough?" (#51, Health visitor)

c) Poor weight gain

Finally, the issue of weight gain (not enough or too much) and failure to thrive was commented upon by 7% of participants, who believed that using BLW might not allow the child to maintain their weight at a healthy level.

"Limited experience, one mum baby dropped centiles drastically but this was due to combination of total breastfeeding and BLW. Another mum used BLW but also spoon fed baby which worked well". (#32, Health visitor)

"There have also been issues with weight gain, as some babies have either put on too much or not gained enough weight." (#33, Health visitor)

Category three: Conditional beliefs

Conditional beliefs, were those such as ambivalence, a preference for a dual approach in weaning (using both BLW and spoon-feeding) or a belief that BLW was acceptable only for certain families. These views were common, with 40 out of 68 (59%) expressing some kind of ambivalent or pragmatic belief. The range of conditional beliefs cited by respondents was 1-3 out of 5 possible subthemes, with a mean of 0.99 beliefs for all respondents and 1.7 for those who had asserted at least one conditional belief.

a) Ambivalence

Ambivalence was a subtheme for 17 participants, with 25% of all respondents expressing this belief. This subtheme was coded for if the respondent suggested in an answer that there was both a positive and negative side to the BLW process.

> *"Cautious. I can see how it would work well if practised well but I can also see how it would work badly if practised badly. There is too much leeway for parents to interpret the rules as they wish." (#12, Health visitor)*

> *"Ambivalent. Proponents are too black and white and dismissive of those who don't follow it. " (#57, Breastfeeding counsellor)*

b) Preference for a dual approach

A dual approach was favoured by 24% of respondents, which was noted if participants said they recommended or experienced a mix of BLW and spoon-feeding, rather than one or the other.

> *"I firmly believe a mixed approach is better i.e. provision of lightly mashed and whole finger foods is better. Babies should be given the opportunity to explore whole foods, but in order for them eat enough to meet nutritional needs, then parents should also be involved in feeding. " (#33, Health visitor)*

> *"Again encouraging a mix of approaches seem to work best and personally I feel parents are happier this way as it allows for flexibility and therefore less pressure." (#46, Registered nutritionist)*

c) Parental anxiety

Parental anxiety was mentioned by 25% of respondents, which seemed to be seen as a barrier to parents effectively using BLW with their children.

"A lot depends on confidence and anxieties of parents and carers." (#26, Health visitor)

"Some mums worry that their baby isn't eating enough food but I remind them that 'food is fun' for the first year and that milk still provides the calories in the first year." (#58, Breastfeeding counsellor)

d) Parental attitude

Overall 19% of respondents highlighted the fact that baby-led weaning was, in their opinion, most often used and/or most effectively used with certain families, for example, where the mother was breast feeding, middle class families and those most engaged with the process.

"The babies I see following it are flourishing. However they do tend to come from middle class backgrounds and have mothers who breastfed, weaned at six months etc." (#9, Health visitor)

"It works well. But the mothers do tend to be older, they've got a good education and they give their family healthy foods. And they read about it a lot. They join all the forums." (#40, Health visitor)

e) Tradition

Finally, for 7% of respondents, tradition was mentioned as a reason why BLW may not be used in a family e.g. grandparents, social circle.

"In the area in which I work I have had very little success in changing attitudes- usually parents are still keen to introduce solids as early as they can" #39, Health visitor

"Where I worked previously parents were more receptive to this method, but up valleys, family members and tradition has a greater influence… first time parents appear more receptive but parents who have weaned at 16 weeks do not see why they can't do the same with subsequent children" (#23, Health visitor)

Aside from the theme of pragmatic beliefs, a subtheme of "need for a balanced diet" was found during analysis of the data as it was mentioned by 9 participants (13% of the total), in response to question 7: Do you have any concerns about baby-led weaning? Respondents said that they had no concerns regarding baby-led weaning with the caveat that parents offered a balanced diet.

How do professionals differ in their views of BLW?

Next, the association between professional group and whether they raised a theme was explored. Table five shows the proportion of each professional group who gave a response within the main themes, with chi square tests exploring whether there was a significant association between role and identifying the theme.

Table 5: Participant professional roles and identification of key themes

	N	**Health benefits**		**Practical benefits**		**Practical issues**		**Safety concerns**		**Intake concerns**	
		N	%	N	%	N	%	N	%	N	%
Public health	36	23	64	31	86	14	39	20	56	16	44
Lay support	13	13	100	7	54	8	62	5	38	0	0
Childcare workers	7	3	43	6	86	3	43	5	71	1	14
Medical staff	6	0	0	3	50	2	33	5	83	6	100
Nutrition specialists	6	5	83	5	83	2	33	4	67	5	83
Significance		X^2 (4, 68) = 20.476, p = .000		X^2 (4, 68) = 8.384, p = .078		X^2 (4, 68) = 2.530, p = .639		X^2 (4, 68) = 4.380, p = .357		X^2 (4, 68) = 24.322, p = .000	

Table light grey shading denotes significance at $p < 0.05$

Significant associations were found between professional role and perceived health benefits [X^2 (4, 68) = 20.476, p = .000] and nutrient and intake concerns [X^2 (4, 68) = 24.322, p = .000]. With regard to health benefits, all lay support workers cited health benefits as an advantage in BLW, while none of those in a medical role saw health benefits to using BLW. Conversely, all of those in a medical role cited possible issues with nutrient or energy intakes, whereas no lay support workers saw this as an issue. Overall, those working in public health roles tended to list benefits whilst those in medical roles tended to list negatives. Next the association between role and specific benefits and potential issues was explored, as shown in the following tables.

Table 6: Participant professional roles and numbers identifying health benefits

	N	Self-regulation		Motor skills		Variety		Healthy food		Encourage breast-feeding	
		N	%	N	%	N	%	N	%	N	%
Public health	36	13	36.1	11	30.6	8	22.2	8	22.2	1	2.8
Lay support	13	9	69.2	6	46.2	1	7.7	2	15.4	6	46.2
Childcare workers	7	0	0.0	2	28.6	2	28.6	3	14.3	0	0.0
Medical staff	6	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Nutrition specialists	6	4	66.7	3	50.0	2	33.3	2	33.3	0	0.0
Significance		X^2 (4, 68) = 15.45, p = .004		X^2 (4.68) = 4.954, p = .292		X^2 (4, 68) = 3.929, p = .416		X^2 (4,68) = 2.650, p = .618		X^2 (4, 68) = 22.486 p = .000	

Table light grey shading denotes significance at p < 0.05

Table 7: Participant professional roles and numbers identifying practical benefits

	N	Psychological		Convenience		Family meals		Food acceptance		Common sense	
		N	%	N	%	N	%	N	%	N	%
Public health	36	11	30.6	7	19.4	8	22.2	20	55.6	4	11.1
Lay support	13	4	30.8	1	7.7	5	38.5	4	30.8	1	7.7
Childcare workers	7	2	28.6	1	14.3	4	57.1	4	57.1	0	0.0
Medical staff	6	1	16.7	1	16.7	1	16.7	0	0.0	1	16.7
Nutrition specialists	6	0	0.0	0	0.0	2	33.3	5	83.3	1	16.7

Significance		X^2 (4, 68) = 2.904, p = .574		X^2 (4, 68) = 2.208, p = .698		X^2 (4, 68) = 4.516, p = .341		X^2 (4, 68) = 11.128, p = .025		X^2 (4, 68) = 1.452, p = .835	

Table light grey shading denotes significance at $p < 0.05$

In terms of positive perceptions of health benefits and practical benefits seen in tables six and seven, Chi square identified significant associations between roles and perceptions that the method promotes self-regulation [X^2 (4, 68) = 15.45, p = .004], encourages breastfeeding [X^2 (4, 68) = 22.486, p = .000] and food acceptance [X^2 (4, 68) = 11.128, p = .025]. Nutrition specialists and childcare workers were most likely to believe the method promoted self-regulation and food acceptance compared to other groups. Meanwhile those in lay support were most likely to see BLW as encouraging breastfeeding. Only one medical participant agreed with any of these benefits, agreeing that BLW seemed to display a degree of common sense.

Table 8: Participant professional roles and numbers identifying practical issues

	N	Mess		Cost/waste		Time		Eating behaviour		Prescriptive	
		N	%	N	%	N	%	N	%	N	%
Public health	36	5	13.9	6	16.7	2	5.6	5	13.9	1	16.7
Lay support	13	7	53.8	1	7.7	0	0.0	0	0.0	3	23.1
Childcare workers	7	3	42.9	1	14.3	1	14.3	0	0.0	0	0.0
Medical staff	6	0	0.0	0	0.0	0	0.0	1	16.7	1	16.7
Nutrition specialists	6	1	16.7	2	33.3	0	0.0	0	0.0	0	0.0
Significance		X^2 (4, 68) = 11.957, p = .018		X^2 (4, 68) = 3.315, p = .506		X^2 (4, 68) = 2.884, p = .577		X^2 (4, 68) = 4.123, p = .390		X^2 (4, 68) = 7.620, p = .107	

Table light grey shading denotes significance at $p < 0.05$

With regard to negative perceptions of BLW within specific roles, there were significant associations between roles and the beliefs that BLW involved practical issues (shown in table eight), with a significant difference in views on mess, with child care workers and lay support workers most often citing this issue [X^2 (4, 68) = 11.957, p = .018]. For safety concerns shown in table nine, medical staff, nutrition specialist and lay supporters felt BLW presented a choking risk [X^2 (4, 68) = 14.549, p = .006].

Table 9: Participant professional roles and identification of safety concerns

	N	Choking		Inappropriate foods		Developmental issues	
		N	%	N	%	N	%
Public health	36	14	38.9	9	25.0	6	16.7
Lay support	13	1	7.7	4	30.8	1	7.7
Childcare workers	7	5	71.4	2	28.6	1	14.3
Medical staff	6	5	83.3	3	50.0	0	0.0
Nutrition specialists	6	4	66.7	4	66.7	2	33.3
Significance		X^2 (4, 68) = 14.549, p = .006		X^2 (4, 68) = 5.032, p = .284		X^2 (4, 68) = 3.315, p = .506	

Table light grey shading denotes significance at p < 0.05

Table ten shows those roles citing intake concerns. The potential for poor nutrient intake was highlighted by medical staff (doctors and public health nurses) and nutrition specialists [X^2 (4, 68) = 16.180, p = .003], while poor energy intake was mainly a concern for medical professionals [X^2 (4, 68) = 11.448, p = .022].

Table 10: Participant professional roles and identification of intake concerns

	N	Poor nutrient intake		Poor energy intake		Weight gain concerns	
		N	%	N	%	N	%
Public health	36	7	19.4	8	22.2	4	11.1
Lay support	13	0	0.0	0	0.0	0	0.0
Childcare workers	7	0	0.0	1	14.3	0	0.0
Medical staff	6	3	50.0	4	66.7	1	16.7
Nutrition specialists	6	4	66.7	1	16.7	0	0.0

Significance		X^2 (4, 68) = 16.180, p = .003		X^2 (4, 68) = 11.448, p = .022		X^2 (4, 68) = 3.574, p = .467	

Table light grey shading denotes significance at $p < 0.05$

In summary, those in different roles had specific concerns, with medical and nutrition personnel being most concerned with possible choking and poor energy or nutrient intake, with lay support workers not considering these potentially concerning and instead seeing mess as more of a disadvantage. Childcare and public health workers saw potential for choking as their biggest issue with BLW, but were less concerned with issues around energy and nutrient intake.

How are professionals advising parents with queries about baby-led weaning?

In question two participants were specifically asked "What advice are you able to offer if a parent asks for guidance on using BLW with their baby?". Thematic analysis of the responses are provided responses as outlined in table seven below, which presents the seven themes identified: no advice (respondents did not feel it was within their role to give advice to parents on BLW); against (respondents viewed BLW negatively and advised against it), official advice (directing parents to official/NHS weaning guidelines), external resources (directing parents to BLW books and resources), experience/common sense (giving personal experience), BLW guidelines/practical advice (advising parents on how to implement BLW) , and support (face to face support).

Table 11: How professionals are advising parents about baby-led Weaning

Response	**N**	**%**	**Examples**
No advice	10	15	*"I don't give parents advice" (#4, Nursery nurse)* *"I feel unable to give them any professional advice as we have no guidance." (#71. Health visitor)*
Against	2	3	*"I tell them not to do it and suggest they read the weaning guidance." (#31, Paediatrician)* *"I would rather not suggest this because it is difficult for us " (#2, Nursery practitioner)*

Official Advice	12	18	*"I do give advice even though we are told not to and to follow NHS advice but it is common sense to me to allow babies to join in mealtimes and eat what you eat?" (#8, Health visitor)* *"Start for life leaflet introducing solid foods, NHS Choices website, birth to five book on line" (#42, Health visitor)*
External Resources	22	32	*"Advice in line with books and articles regarding BLW, such as Gill Rapley's". (#55, Breastfeeding counsellor)* *"I direct them to the Rapley book and websites. I give them leaflets on weaning babies" (#3, Nutritionist)*
Experience /Common Sense	9	13	*"To follow common sense and give the baby some of what you are eating as long as low in salt." (#10, Registered dietician)* *"Common sense and my own experience and reading. But nothing official really." (#40, Health visitor)*
BLW guidelines/ practical advice	29	43	*"Ensure that the infant is developmentally ready i.e. able to sit unsupported, start off with soft food." (#17, Health visitor)* *"I am able to talk them through the process of baby led weaning and give them suggestions and also consider what the parent is interested in as well as the milestones of the baby and if it is appropriate to start e.g. premature babies" (#37, Health visitor)*
Support	3	4	*"Face to face discussion and support, peer support" (#66, Infant feeding specialist)* *"I have a baby group where BLW is practiced with children of 6 months or over and discussed with the mums of younger babies. I give a variety of different foods at this group so that parents can have some idea what to give and have confidence doing this in a controlled environment" (#28, Health visitor)*

Clearly, a range of responses is being seen, with almost half (43%) being able to give parents some background advice on how BLW works in practice, ranging from what to look out for in terms of developmental readiness to a full outline of the BLW method, while 32% were happy to direct parents to external sources of information, such as books and websites.

The way forward: Information, Training and knowledge

Alongside the critique of the method, participants raised the idea that if they were going to support or advise mothers with the approach, there was a need for more training, research and information regarding baby-led weaning as shown in table twelve. These three subthemes: training, research and information were identified by 22 of the respondents (32%), with a range of 1-3 codes generated per participant who identified themes.

Table 12: Requests for further research and training

Request	N	%
Further training	12	18%
Further research	6	9%
Lack of information	7	10%

Further training

The need for training was mentioned by 12 participants (18% of the total or 55% of those who identified this theme) as shown in table twelve. Having formal training was mentioned by a limited number of respondents, as a lack of national recognition and guidelines regarding BLW means that there may be little training available for health professionals.

> *"Nervous. To me it makes complete sense but we have had no formal training. I want to say 'what a great idea' but then I worry about what would happen if something went wrong" (#71, Health visitor)*

> *"I would really like more training so I know if what I am telling parents is right or wrong." (#40, Health visitor)*

Further research

The need for more academic research was also identified by the 6 respondents (9% overall or 27% of those who mentioned one of these subthemes), who suggested that lack of evidence was stopping them from recommending BLW or indeed causing them to see the method as unsafe.

> *"It is something I would like to see study results of. I do encourage mums to let baby eat to appetite" (#44, Health visitor)*

"Unhappy - parents are using this method when there is no evidence for its effectiveness. In my opinion it is just another fad. We have a perfectly good system for feeding babies and do not need mothers and their desire for alternate approaches deciding that they know best for their babies. I see the impact of this all the time - especially with vaccinations." (#31, Paediatrician)

Lack of information

Finally, lack of information available to both parents and care providers was another subtheme in this category. 7 respondents (10% overall and 32% who recorded a positive code in this theme) cited this as an issue for them in their practice and for parents attempting to use BLW with their children.

"In my experience many professionals are not happy and confident about supporting parents to try BLW due to lack of guidance and support from dietetics departments or paediatricians and ultimately government departments such as NICE." (#68, Infant feeding coordinator)

"Many HCPs don't know a lot about it and are not able to support parents with it - parents tend to get pushed towards purees & feeding more solids if there are and queries regarding weight gain or sleep, particularly during the first year." (#61, Breastfeeding counsellor)

Summary of findings

In summary, the views about baby-led weaning expressed by this survey were more positive than negative, with 93% of participants (n = 63) stating at least one positive view and 84% (n = 57) expressing at least one concern. However, a majority of respondents (n = 52, 76%) suggested both positive and negative aspects to baby-led weaning, with the remaining 24% (n = 16) either stating just advantages or disadvantages to the method, with 11 (16%) being wholly positive and 5 (7%) having only negative views.

When looked at together, the positive themes and subthemes (practical and health benefits) were mentioned by 70% of respondents. Negative themes (practical issues, health concerns, safety issues) were mentioned by 58% of participants. The most common perceived health benefit was self-regulation i.e. the ability to eat according to appetite (38%) and the most commonly cited health or safety issue was that of choking (43%).

In terms of the need for more information, training and research on baby-led weaning, 32% of respondents highlighted this as an issue in their practice, suggesting a real need for further academic study and practical help for health care advisors and practitioners dealing with parents of infants navigating the weaning process. This is backed up by the findings of the second question in the survey, which asked respondents about their advice for parents wishing to know about baby-led weaning. In this set of responses, only 2 health care practitioners said they would advise against using BLW and 10 participants said they gave no advice to parents, because of their role or legal requirements. However, of the remaining 57 care providers, 22 (39%) directed parents to external resources such as websites, perhaps due to unfamiliarity with BLW or a reluctance to recommend its use. On the other hand, 44% (n=30) of participants were able to offer an overview of baby-led weaning guidelines, suggesting a reasonable level of knowledge within this sample of practitioners.

Discussion

This study presents the experiences and opinions of a sample of UK health and child care professionals regarding baby-led weaning (BLW). It demonstrates the visibility of BLW in that all but one respondent had heard of the approach and almost all had experienced it in their professional lives. Although the majority of participants had at least one positive comment about BLW, the study also emphasised several concerns, and at least one concern was raised by over 80% of participants. The findings also demonstrated a desire among the professionals for more research, training and official guidance to allow them to advise parents more effectively.

Looking at the findings in more depth, it was clear that both positive and negative views of BLW were held, often simultaneously, by participants. Considering positive views first, two key benefits emerged from the data: practical and health benefits. Notably, the concept of BLW offering practical benefits was the most common benefit mentioned, over and above benefits to health.

Exploring perceived practical benefits first, these included increased food acceptance (including lack of fussiness and exploration of novel foods), increased family time and social benefits (including reduced costs and greater convenience for parents). This supports results of previous research into perceptions of health care professionals from New Zealand and Canada, which found that convenience for parents was a perceived benefit of BLW (Cameron et al., 2012a; D'Andrea et al., 2016). The suggestion that BLW is convenient because it enables babies to join in family meal times, also echoes findings in previous studies conducted with parents following the method (Brown and Lee, 2013; Cameron, Taylor, & Heath, 2013; Komninou et al., 2019; Rowan and Harris, 2012). Family mealtimes as highlighted in the survey are both convenient because parents can feed themselves, while their baby does the same, and may also lead to greater social interaction and possibly less stress for parents. If BLW is encouraging this behaviour it is a significant benefit. Research shows that shared family meals can increase positive behaviours and health outcomes, such as healthier eating and dietary patterns, normal weight and reduced fussiness in childhood and adolescence (Hammons and Fiese, 2011; Powell, Farrow, Meyer, & Haycraft, 2017). However, the financial benefits highlighted by some respondents here have been challenged by recent findings from the BLISS RCT in New Zealand, which showed BLW was very slightly cheaper for parents, but not significantly so, in spite of being perceived as such (Bacchus et al., 2020).

Notably food acceptance in this context was coded as a practical rather than a health benefit, because of the reduced stress and anxiety for parents in not having to manage or worry about a fussy infant. Over half the participants in the study raised this idea. Previous research in this area has been generally consistent, with infants using BLW being perceived as less fussy (Brown and Lee, 2015; Fu et al., 2018; Komninou et al., 2019), although one small study found no difference between groups when parents were asked whether their child was a picky eater (Townsend and Pitchford, 2012).

There are a number of reasons why BLW may lead to reduced fussiness in infants. It is possible that introducing infants to foods in their whole rather than pureed form increases recognition and therefore acceptance of foods. Research suggests that infants often need to be exposed to new foods numerous times before they accept it (Birch and Marlin, 1982; Caton et al., 2014). Potentially BLW need fewer exposures as the food is given in its natural form and doesn’t ‘change’ over time e.g. moving from purees to solid form. An infant will learn from their first exposure what a carrot tastes like if they encounter the food in its natural form. Pureed carrot or a mixed puree including carrot may not invoke the same responses in terms of taste and appetitive learning (whether positive or negative) as a recognisable piece of carrot. However, there are many potential causes of fussiness including genetic susceptibility, as discussed in the review of literature, which make associations with weaning style hard to disentangle.

A minority of the respondents suggested that BLW might lead to greater fussiness or a narrower variety of foods consumed if the baby is allowed complete autonomy over their food choices. It is feasible that a baby would avoid foods they did not enjoy and if the child had a preference for sweet foods, for example, this could lead to rejection of healthier foods with a bitter or sour flavour profile such as green vegetables, which may be less palatable to children. So it would seem possible for this phenomenon to occur and warrants investigation: do certain infants introduced to solids using BLW have narrow food choices and does this change over time? Or as found by Caton et al (2014), does repeated exposure to these less palatable foods, lead to acceptance for younger children?

The second major positive theme raised was the belief that BLW offered health benefits to infants including self-regulation of appetite, improved physical co-ordination, a healthier diet and increased food variety. These views again echo the findings of previous studies which found that professionals perceived advantages to baby-led weaning such as increased food variety, self-regulation and improved fine motor coordination (Cameron et al., 2012a), while other research has found similar views in parents using BLW in the UK (Brown and Lee, 2013).

If infants following BLW are able to show a greater degree of self-regulation there are a number of explanations for this impact. Predominantly the pace and length of meals are determined by the baby, allowing them greater autonomy over their satiety, as opposed to traditional weaning where an adult feeding the child may consciously or otherwise control the amount or pace of feeding (Brown and Lee, 2011c). Indeed, several study participants highlighted lengthier meal times as a disadvantage of BLW, so there may be a need for education for both parents and those interacting with infants on the benefits of a more relaxed, longer mealtime in enhancing appetite and satiety cues.

Self-regulation of appetite is seen as beneficial for health because of its association with weight, with a greater degree of satiety regulation linked to lower weight in the literature (Bray and Bouchard, 2019; Faith et al., 2012; Llewellyn et al., 2014; Viana, Sinde, & Saxton, 2008). If an infant is able to respond to satiety cues from the beginning of their relationship with solid food, this ability may extend into childhood and beyond, reducing the likelihood of caloric intake in excess of requirements, which is the basis for weight gain (Bray and Bouchard, 2019).

However, alongside positive perceptions, participants held a number of negative beliefs about the method. Notably some of these were in direct opposition to the benefits listed e.g. increasing fussiness or weight issues, or decreasing nutrient intake. The main disadvantages were based around safety, nutrient intake and practical issues.

In terms of safety concerns, half of participants raised this issue specifically around choking. This issue was also raised by professionals in the previously mentioned Canadian study (D'Andrea et al., 2016) and the BLISS project, in which 30% of parents reported one or more episodes of choking when using BLW (Cameron et al., 2012a). However, it would seem from the description of these incidents, which stated that the infants were able to expel the food from their mouth through coughing, that the incidents may have been gagging rather than choking. Gagging is a reflex designed to bring large pieces of food to the front of the mouth for chewing and/or expelling, which changes and modifies during normal development (Naylor and Morrow, 2001). Further research on choking in families using BLW has not found any significant difference in incidence between weaning styles (Brown, 2018; Fangupo et al., 2016).

A second common concern was the use of inappropriate foods. This was partly linked to safety concerns e.g. small, hard foods such as raw apple and nuts are considered a choking risk, and partly due to nutrient intake concerns, such as high-sodium, processed foods. These concerns around unsuitable food choices were also raised in the New Zealand study of health professionals (Cameron et al., 2012a), particularly around potential issues with failure to thrive or gain weight, poor food choices and reduced iron intake.

This could be an issue if families do not alter their food preparation or choices to account for the low salt intake required by infants . In one study of intakes in families using BLW, where participants were offering family foods over 50% of the time, the salt and saturated fat content of family diets exceeded government recommendations (Rowan and Harris, 2012), which has implications for the health of infants being exposed to these foods.

Infants of 6-12 months should have no more than 320-350mg/day yet the family diets in this study contained almost 2800mg/day. It appeared that parents had not modified their diet to meet the requirements on their BLW infant, yet many were still offering family foods.

However, it is worth noting that traditional weaning styles do not preclude the feeding of inappropriate foods. One investigation into commercially available baby foods in the UK found that they were less nutrient dense and contained more sugar than home-made purees (Garcia, Raza, Parrett, & Wright, 2013), while a wide-ranging survey of UK baby-foods found that most infant foods contained more energy than was estimated to be required, they were predominantly sweet even when vegetable based and portions were large (Crawley, 2017). Furthermore, simply pureeing the foods being eaten by adults may lead to the infant consuming excessive sodium or sugar.

Linked to poor food choices being offered, another common theme was concern surrounding whether the combination of foods offered and infant skill would enable sufficient nutrients to be consumed. Some participants believed this might exacerbate fussiness or underweight. However, it is important to consider these concerns within context. Guidance for nutrient and energy intake from solid foods for infants under one year highlights the need for a gradual approach and a predominantly milk based diet. Overall, infants only need around 200 calories per day from solid foods between 6-8 months rising to 300 kcal per day in infants 9–11 months (WHO, 2009).

One area that is of concern is iron intake. Breastfed infants need additional iron from six months of age (as it is already added to infant formula). In traditional weaning, this can be supplied by iron-fortified infant cereal, which can be spoon-fed by an adult, however, unless care is taken in baby-led weaning, good sources of iron may be lacking. For example, one study found that first foods for strict BLW adherents consisted mainly of fruit and vegetables, which although high in water soluble vitamins are low in iron (Cameron et al., 2013), thus it is vital that the diets of babies weaned using BLW are examined to ascertain the levels of iron-rich foods they contain, as well as their energy intake.

The BLISS RCT attempted to address some of these issues by creating and pilot testing a modified version of baby-led weaning, which emphasised the regular offering of iron-rich and energy-dense foods, as well as the avoidance of foods associated with a higher risk of choking (Cameron et al., 2015). The initial results of the pilot study showed babies in the BLISS group were offered significantly more high-iron foods, and less high-risk choking foods than their counterparts in the BLW group. This demonstrates that some of the perceived risks of baby-led weaning may be mitigated with extra support and advice for parents from healthcare providers. However, this has financial implications due to the cost of providing these resources, especially if the use of BLW continues to grow and is implemented more widely within the UK population.

In terms of practical issues, respondents raised the impact of potential cost linked to provision of fresh foods or food waste due to babies dropping food on the floor or not eating the food offered. This was seen as a barrier to some families participating in BLW by 15% of respondents overall, and these concerns were also uncovered in the aforementioned studies exploring HCPs opinions (Cameron et al., 2012a; D'Andrea et al., 2016) and in fact this topic was specifically explored recently in a New Zealand study, which found little difference in cost to parents between methods (Bacchus et al., 2020). The cost and resources such as cooking facilities required for providing fresh foods were two reasons flagged by participants to explain why BLW may not be suitable for all families. Issues with mess and waste were raised in another UK study, as was the potential cost of the waste, however the parents involved stated that these problems diminished over time and they were able to adapt, for example by offering less messy foods when eating in public (Brown and Lee, 2013). Indeed, ways of minimizing wastage, such as using small amounts of thawed frozen vegetables or fruit rather than fresh, could be highlighted in future educational materials created for health care providers advising on BLW.

Finally, around half of participants expressed a degree of ambivalence or conditional responses based on individual context of families in their views of the method . Such beliefs included acknowledgment of both positive and negative aspects to BLW, a preference for a mixed approach to weaning (using BLW alongside spoon feeding), experience of parental anxiety around BLW, even if held in a positive light, or a view that BLW was suitable only for certain families or its use was hampered by tradition. Ambivalence was widespread among the survey respondents, with just 12% having firm views either for or against baby-led weaning.

Almost a quarter of participants recommended or had experienced parents using a mix of traditional spoon-feeding and baby-led weaning, therefore it would seem that a dual approach may be fairly common. This is backed up by results from the BLISS project, which found that strict adherence to baby-led weaning methods was only followed by 8% of the study group (taken from the general population), while 21% followed a self-identified BLW method which was actually mixed with parent-led feeding (Cameron et al., 2013). Given that much of the current research in this area has been focused solely on baby-led weaning or in direct comparison to traditional weaning, it would seem prudent to investigate the use of BLW in conjunction with spoon feeding i.e. whether a mixed approach shares the perceived benefits or disadvantages of a more polar approach, and indeed whether a rigid approach to BLW is justified.

Parental anxiety over certain aspects of BLW was identified as a barrier to its effective use, either preventing parents from initiating BLW or making it more likely that parents would abandon the method after a brief experiment. Some of this anxiety was related to possible choking incidents or mess created when babies feed themselves, but may reflect the differences seen in the personalities and feeding styles of mothers who chose to implement BLW versus those who do not, as previously discussed (Brown and Lee, 2011c; Komninou et al., 2019). If health care providers felt more confident in the advice they are able to give parents enquiring about BLW, it is possible they may be able to assuage some of this anxiety and parents would feel more confident using the method.

Interestingly, almost a fifth of respondents believed that BLW was only suitable for or was only seen in certain families, such as those where the mother is breast-feeding, where the parents are educated, from the middle-classes and where much interest is shown in the method. This echoes previous research, which has shown that mothers who use BLW tend to be older, better educated, married and take at least a year's maternity leave (Brown and Lee, 2011a, 2013). However, the tenets of BLW are straightforward and do not require a high level of education to implement, therefore it would be interesting to examine and perhaps challenge the assumptions made by professionals as to which children would do well using a baby-led approach. Is prejudice from certain professionals reducing the accessibility of baby-led weaning to mothers from lower SES backgrounds?

Training and training needs

When asked what advice they were able to give parents interested in baby-led weaning, less than half of respondents were able to give basic guidelines and over a third directed parents to external resources such as websites and books, rather than their own resources, which may suggest a lack of confidence in their own knowledge on BLW. However, when asked directly about confidence in their knowledge of BLW, 62% of all participants and at least half of participants in each of the roles felt confident, rising to 84.6% of lay supporters, which suggests that directing parents to external resources may be related to an absence of available educational materials, as well as a lack of knowledge and confidence.

This in fact reflects one of the most pertinent findings of this study: the desire from professionals for further training and to have official recommendations on baby-led weaning, so that they are able to feel validated and supported in their advice to new parents. Over half of participants wanted more information and training on BLW, with no significant relationship between response and profession. This may be due to a lack of official standpoint on BLW by the Department of Health, leading to reluctance to advise parents when they themselves have received no formal training on BLW and being concerned with possible repercussions of advising without official approval. Participants may have felt confident in their personal knowledge but without officially sanctioned training and guidelines, may be hesitant to advise parents in a professional context.

Given that health professionals are an important source of advice for new parents concerned about introducing solid foods to their babies (Moore, Milligan, Rivas, & Goff, 2012), it is vital that these health and childcare workers have evidence-based research, up-to-date information and official guidelines on which to base their support: therefore it is imperative that the evidence base for baby-led weaning is improved with studies investigating some of the concerns around safety and intake that the professionals in this study and parents they advise, have highlighted about the baby-led approach.

As the evidence base for baby-led weaning grows alongside the popularity of the method, it would seem appropriate to provide specific training for health and childcare providers in this area. Training courses for health visitors and those working with infants and parents would be relatively cheap and convenient to provide online in the form of webinars, given the rise in the use of video sharing platforms such as Zoom during the last year. Presentations could be recorded and provided to those unable to attend in person, while handouts for both professionals and those for their clients can be sent to participants after attending. Courses could potentially be validated for CPD purposes by professional organisations such as the UK Nursing and Midwifery Council or PACEY (the Professional Association for Childcare and Early Years). The benefits of the webinar format include participants being able to attend from wherever they live or work and that they can interact in real time using Chat facilities to ask questions and give feedback. The facility would only be limited by Internet access

It would also be relatively easy and cost-effective to supply professionals with written information in the form of a booklet or eBook, either for internal training purposes outlining the evidence base supporting safe use of baby-led weaning in the community, or for distributing to families wishing to use BLW with their infants who need advice and support from health visitors, GPs or peer support workers. For HCPs this literature could include results of studies on BLW which underline its safety and sufficiency as a method for weaning infants, addressing some of the concerns which were brought up in this study, while childcare workers, most of whom expressed concerns with choking, could be assured that the evidence around BLW and choking was reassuring (Brown, 2018; Fangupo et al., 2016). For resources used for parents, practical tips on foods suitable for infants could be included, with reminders of the importance of avoiding salt for babies and highlighting foods which are choking hazards.

Limitations of the study

Several limitations could be applied to this study. Firstly, the sample of professionals working with parents and infants was self-selected, which may have led to only those with firm views about baby-led weaning taking part. However, although the views expressed on BLW were more positive than negative, the vast majority of respondents had both positive and negative views on the method. It could be argued that the vast majority of participants were neither overt proponents or nor critics of the method and were therefore able to give a balanced view of its pros and cons. The size of the sample was relatively small, however data saturation was reached (the point when no new themes are identified within a new interview or respondent) and the numbers exceeded the level desired in a qualitative descriptive study (Guest, 2006).

Even though a variety of professional roles were reached, care should be taken in generalising these results to the entire population of UK health and child-care providers due to the small sample size. In-depth, in person or phone interviews would have would have provided more detail about the participants views, however this approach was not feasible within the confines of a PhD candidacy and may have reduced participation due to the burden on those taking part. There were further methodological limitations such as using the internet for recruitment and self-selection of respondents, as discussed in chapter three.

In addition the inclusion of child care workers' views in the study when they had not specifically been sought may be viewed as a limitation, but in fact these professionals experience and aid in infant feeding on a daily basis and their views have not been reported in any existing research on baby-led weaning, which gives an interesting perspective to this work.

What questions now need to be asked?

We know that further research is needed into the potential outcomes of following a baby-led weaning approach for infant health. Such research will enable the development of guidance and support for new parents to move forward, and for health professionals to receive the evidence-based training that they desire. This study has helped identify the concerns that health and childcare professionals have regarding the baby-led approach, offering insight of where to target further research into exploring those concerns in greater depth.

Overall the professionals in this survey identified a number of potential benefits and concerns around the baby led approach which often focused on two sides of the same issue. Two of the most common concerns were around nutrient intake (either potentially enhanced or reduced) and healthy weight (either supporting healthy weight gain or leading to under or even overweight).

Several studies have focused on weight of infants using BLW compared to those being spoon-fed (Brown and Lee, 2015; Jones et al., 2020; Townsend and Pitchford, 2012), but few have examined the nutrient intake of these infants (Alpers et al., 2019; Dogan et al., 2018; Williams Erickson et al., 2018). Most research that has been conducted on nutrient intake has been conducted by the BLISS group in New Zealand , meaning that it may not be fully relevant to the practice and diet of those living in the UK. Understanding how the BLW approach affects exposure and intake is therefore an important but complex challenge that cannot be fully answered in a single study.

Based on this, the following research questions will form the remainder of the thesis, comparing infants following a baby-led or traditional approach:

R2. Does food acceptance differ between weaning groups?
R3. What are the differences in energy intake between groups?
R4. What are the differences in macro/micronutrient intake between groups?
R5. Is BLW sufficient or significantly different to traditional weaning?

To explore these questions, the next stages of the thesis will consist of three interlinked studies which explore the topic of nutrient intake in BLW versus spoon-fed infants in more depth, balancing sample sizes with method of dietary assessment to give a detailed picture of exposure, eating behaviour and intake in infants following different approaches. It is hoped that these findings will help inform an important gap in the infant feeding evidence base in the UK.

The remaining three studies will consist of:

1. An internet based survey targeting parents of infants 6-12 months of age who have started the weaning process, examining perceptions of children's eating behaviours such as fussiness and satiety responsiveness, enjoyment and preference for different foods and a Food Frequency Questionnaire to assess exposure.

2. A twenty-four hour recall to assess dietary intake in a more in depth manner that formed part of the internet survey outlined in study two and was completed by a subset of study two participants.

3. Finally, a weighed three-day diet diary to assess energy and nutrient intake in a smaller group of participants.

For an overview of how these studies fitted together, please refer to the schematic diagram on page 16.

The use of three different dietary assessment tools will balance depth of investigation and sample sizes. The internet survey will be aimed at a wide group of participants but has a low response burden. The 24 hour recall is a more in depth tool, making it less convenient, and it is anticipated that the number of respondents, while still being recruited via the internet, will be lower than the Food Frequency Questionnaire. Finally, the weighed three day diet diary has the highest respondent burden and it is anticipated that this study will therefore have the fewest participants. However, this study will give the most detailed data on dietary intakes in infants who are using baby-led weaning. Overall, bringing the findings from this study together will help illustrate the eating behaviours and nutrient and energy intake of infants according to weaning approach.

Chapter 5: A survey of dietary patterns and eating behaviour in baby-led and traditionally weaned infants aged 6-12 months

Introduction

The findings from the previous study on attitudes and opinions of professionals about the use and impact of baby-led weaning demonstrated that two interlinked concerns around the baby-led weaning approach were common: nutrient and energy intake and fussy eating and appetite control. Whilst some participants perceived the method to promote acceptance of a wider range of foods, a more varied nutrient intake and a healthier weight, others were worried it could exacerbate malnutrition and picky eating behaviour.

The first step in exploring these concerns is to therefore examine whether differences in eating behaviour can be identified between infants following a baby-led or traditional approach. This includes aspects of fussy eating, satiety responsiveness and wider acceptance of food, alongside the exposure of infants to different food types.

Research has explored some aspects of infant eating behaviour in relation to weaning approach. As noted previously, research has identified that infants following a BLW approach are less likely to be rated as fussy eaters by parents (Brown and Lee, 2015; Fu et al., 2018; Komninou et al., 2019), although research into perceived satiety responsiveness is more mixed (Brown and Lee, 2015; Komninou et al., 2019; Taylor et al., 2017). Little research has explored perceived liking of individual foods, with just one small study assessing preference for different food groups (Townsend and Pitchford, 2012) and to our knowledge there has been no investigation of exposure of BLW infants to various foods.

The aim of this second study was therefore to examine the perceived eating behaviours of infants aged 6 – 12 months following a baby led or traditional weaning approach in the UK. Specifically, it sought to explore the following questions, comparing infants following different weaning approaches:

1. What foods are infants being exposed to?
2. Do infants vary in their liking of different foods?
3. Do infants vary in ratings of fussy eating and satiety responsiveness?

This study was designed to contribute data to research questions

R2. Does food acceptance differ between weaning groups?
R4. What are the differences in macro/micronutrient intake between groups?
R5. Is BLW sufficient or significantly different to traditional weaning?

Methodology

Design

This study used an online, self-report survey, incorporating a number of validated tools to measure infant food exposure, enjoyment and eating behaviour. A survey was chosen to collect this data in order to allow numerical comparison of behaviours between weaning groups (Singh, 2007). This method allowed pre-existing validated tools to be combined into a questionnaire to enable valid methods to be used to make these comparisons. Questionnaires allow large amounts of objective quantitative data to be collected in a cost and time effective way. Tick boxes help reduce researcher bias by using scales and definitive answers that prevent personal distortion or interpretation of responses (Singh, 2007). They are useful for measuring behaviours and outcomes rather than exploring the 'why' questions, making it suitable for the aims of this study.

As in the previous study, an online approach was used for recruitment and the advantages and disadvantages regarding this method have been discussed in chapter three containing the methodological background of the thesis. This structure allowed the participant to complete the survey at a time of their convenience, which is important for parents caring for infants. Likewise, the method offers anonymity which may help increase honesty and accuracy in responses due to the sometimes sensitive nature of infant feeding research. It may help reduce social desirability in parents giving the responses that they feel they should give, rather than those which are accurate (Zhang, Kuchinke, Woud, Velten, & Margraf, 2017). For these reasons this method of data collection is now commonly used in infant feeding research (Alpers et al., 2019; Brown, 2018; Cameron et al., 2013; Finnane, Jansen, Mallan, & Daniels, 2017; Fu et al., 2018; Morison et al., 2016; Townsend and Pitchford, 2012) .

Participants

Parents with a baby aged 6 – 12 months living in the UK completed the survey. Inclusion criteria included the parent being age 18+, having an infant who had started solids foods and being involved in the infants diet to the extent they could reliably complete the questionnaire i.e. participating in most mealtimes, purchasing food or having an overview of what the infant ate in other settings such as childcare. Exclusion criteria included infants with significant health issues or having a low birth weight (classed as under 2.5kg), as this might affect diet offered, infant feeding skills, or parental anxieties around weaning.

Approval for this study was granted by the Swansea University Department of Psychology Research Ethics Committee. All participants gave informed consent prior to inclusion in the study. Ethical considerations were made with respect to the principles for research on human subjects outlined in the World Medical Association Declaration of Helsinki. As such, all subjects were provided with information about the study and were informed regarding their consent and the anonymity of their data and responses.

Measures: reliability and validity

The survey, hosted online by SurveyMonkey, consisted of a number of sections. These included:

1. Demographic information: Maternal education, household income, age and employment. Infant birthweight and sex.

2. Milk feeding: Milk feeding at birth (breast or formula) and duration of breastfeeding and timing of any introduction to formula milk were also included.

3. Timing of introduction to solid food in weeks

4. Method of introducing solid foods: Participants were given the definition of "Baby-led Weaning" below and asked to identify whether they were following the method 'strictly', 'loosely' or 'not at all':

"Baby led weaning is the process of placing foods in front of your baby and letting them feed themselves - picking the food up themselves and putting it in their mouths unassisted, rather than being spoon-fed by a parent. This could involve them using a spoon themselves. Baby-led weaning tends to involve offering the baby family foods rather than offering pureed foods".

5. Infant eating behaviour. This was measured by completion of the Children's Eating Behaviour Questionnaire (CEBQ) created by Prof Jane Wardle's team at UCL (Wardle, Guthrie, et al., 2001). The original dimensions used were derived from existing literature on eating behaviour and interviews with parents on their child's eating behaviours and included responsiveness to food, enjoyment of food, satiety responsiveness, slowness in eating, fussiness, emotional overeating, emotional undereating, and desire for drinks, as described in section 2.2.1 of the literature review in chapter two.

   Although the CEBQ was originally designed to measure eating behaviour in older children, it has been used widely in subsequent research around infant eating behaviours in relation to solid foods including studies on baby-led weaning (Brown and Lee, 2015; Cao et al., 2012; Daniels et al., 2015; Domoff, Miller, Kaciroti, & Lumeng, 2015; Komninou et al., 2019). In this study, the CEBQ was adapted to include scales exploring responsiveness to food, enjoyment of food, satiety responsiveness, slowness in eating and fussiness and respondents selected their answer via a five point Likert scale.

   To ensure that the use of these scales was still a valid measures when used in this way, Cronbach's alpha was computed for items within each scale. Cronbach's alpha is a measure of internal consistency of items that are grouped together as a scale, calculating how closely related these items are as a group. When Cronbach's alpha was measured for the scales used here, all values were acceptable including.728 for enjoyment of food, .776 for satiety responsiveness, .835 for fussiness and .844 for food responsiveness, demonstrating good internal validity in the four dimensions used in this study.

6. Exposure to different food groups, including whether and in what form the food was eaten e.g. whole, mashed, puree. This was measured by completion of a Food Frequency Questionnaire (FFQ), consisting of commonly eaten foods adapted from previous research (Marriott et al., 2009; Marriott et al., 2008; Robinson et al., 2007) and a question on whether the food had ever been eaten, the results of which were termed "exposure". FFQs are a cost-effective, easy to administer dietary assessment tool and although they do not provide the level of detail is found in other instruments such as 24 hour recalls and weighed diet diaries, there is supportive evidence for the successful use of FFQs in studies involving infants' food consumption (Du Toit G, 2008; Sharma et al., 2013). They are particularly suited to the comparison of diets for large groups, rather than individuals, as was the case in this study. In this instance, the FFQ used was adapted from one devised by the Southampton Women's Study to assess the diets of infants of 6 months and 12 months of age, which was validated against 4 day weighed food records of 12 month old infants taking part in the same study, as well as data from UK studies using 24 hour recalls (Marriott et al., 2009; Marriott et al., 2008; Robinson et al., 2007).

7. Enjoyment and preferences for different foods, measured using a 5 point Likert scale, from dislikes a lot to likes a lot. Preferences for foods on a similar scale had been assessed in previous work comparing baby-led and spoon-fed weaning groups (Townsend and Pitchford, 2012). Preference was also assessed in the BLISS study, using 21 foods and a modified 5 point scale (Morison et al., 2018).

Procedure

Participants were recruited by placing adverts including a link to the questionnaire on Surveymonkey.com on social media sites such as Facebook parenting groups and Twitter and sharing was encouraged to spread the link to as many people as possible. If participants wished to take part, they could click on the link to the survey, which had an information page describing the study and its aims. Informed consent questions were required to be completed for the survey questions to load and contact information was given for both the researcher and supervisor if further questions were raised. Participants gave details of their postcode to ensure UK participation. A debrief loaded at the end of the questionnaire encouraging participants to seek advice from a healthcare provider if the survey had raised any issues for them. Participants were also given details on how to request a paper copy of the questions and consent forms and how this could be returned to the researcher anonymously.

Using social media for recruitment was a technique previously used to optimise the reach of surveys in a non-personal and indirect manner. The benefit and limitations of using the internet for recruitment have been discussed in chapter three and will be considered in greater depth in the general discussion.

Data Analysis

Data were analysed using IBM Statistical Package for Social Sciences (SPSS. V 22, IBM). In order to compare different intakes and behaviours between weaning groups, the participants were divided into three different groups, to reflect the way that baby-led weaning can be perceived and practiced in reality. Parents were presented with a definition for BLW (see Measures) and asked to identify whether they used the method and whether this was in a strict or loose manner. This method of self-identification had been used in previous studies of parents using BLW (Cameron et al., 2015; D'Andrea et al., 2016; Rowan and Harris, 2012; Townsend and Pitchford, 2012).

Three different age groups were created to further explore differences between weaning groups because of the different foods and amounts eaten over the course of the second six months of a child's life. For example, an infant of six months old who is just starting baby-led weaning may be consuming very little at each meal, whereas at 12 months old they may be a competent self-feeder eating a variety of family foods three times a day. Hence, the sample was divided into three age groups: 6-8 months, 9-10 months and 11-12 months of age.

With regard to statistical tests, one-way ANOVA and Chi Square tests were used to explore demographic differences and characteristics of parents such as parity, according to weaning group. Post-hoc Bonferroni tests were carried out to clarify any significant differences between the groups.

Analysis of the CEBQ was carried out using ANOVA, followed by a post-hoc Bonferroni test. Covariates were controlled for, when possible, using MANCOVA. Differences in the Food Frequency Questionnaire were analysed by ANOVA, while exposure to different foods was explored using Chi Square. Enjoyment of foods was examined with Fisher's Exact due to the low numbers who had tried particular foods.

At this point it should be noted that when conducting multiple analyses on a large dataset there is a risk of finding significant results by chance, rather than finding a true relationship between variables. This is known as data dredging or p-hacking, as is an issue particularly when statistically significant results are required for successful publication (Smith and Ebrahim, 2002). When significance is set to $p = 0.05$, this will lead to 1 in 20 significant results being coincidental, purely due to the fact that all data sets have patterns that occur by chance, leading to erroneous conclusions. HARKing or Hypothesising After the Results are Known is another way data can be controlled, as the researcher reports a post-hoc hypothesis as if it were an a priori hypothesis, once data has been collected and patterns may be seen where once they were unanticipated (Kerr, 1998; Rubin, 2017). Data can also be manipulated by looking at sub-groups within a dataset, especially when groups are chosen after data collection which can introduce selection bias into the analysis, meaning results cannot be generalised to a larger population (Smith and Ebrahim, 2002).

However, there are several ways these effects can be mitigated. Confounders can be controlled for, as they were in this analysis, to reduce selection bias, and the use of different weaning groups (baby-led and traditional weaning) was set out before data collection (a priori), as a fundamental outcome of the study was investigation of differences between these groups, as well as the various age groups. In addition, post-hoc Bonferroni testing was used to identify the source of significant results and few results did not survive testing, suggesting the findings were therefore valid. Finally a post-hoc Bonferroni correction was applied ($p < 0.001$) when multiple tests were used, such as the Exposure, Food Frequency Questionnaire and Enjoyment of foods analyses. This lower significance level reduces the likelihood of multiple test results being due to chance, strengthening confidence in the findings.

Results

Three hundred and ten parents completed the survey, with two hundred and ninety seven participants meeting the inclusion criteria. Three participants were excluded for incomplete information and ten were excluded for having babies with a low birth weight. Two hundred and eighty one mothers, six fathers and ten participants who did not disclose their sex, took part. Mean age was 31.8 (SD: 5.1) [range 18 – 44]. 62% were first time parents (n = 184) and 38% had more than one child (n = 113). The mean age of the infants in the study was 36.7 weeks (SD: 8.2). The mean birth weight of the infants was 3.5kg (SD: 0.5), while N = 141 (47.5%) were female and N = 156 (52.5%) were male. Full parental demographic details are shown in table thirteen.

Table 13: Participant demographic background

Indicator	Group	N	%
Age in Years	≤19	5	1.7
	20 – 24	20	6.7
	25 - 29	73	24.6
	30 - 34	108	36.4
	≥35	91	30.6
Education	No formal qualifications	3	1.0
	School (GCSE)	8	2.7
	College (A Levels)	48	16.1
	University	138	46.5
	Postgraduate	98	33.0
	Prefer not to disclose	2	0.7
Employment	Full time	46	15..5
	Part time	47	15.8
	Parental leave	141	47.5
	Not working	63	21.2
Marital Status	Married	225	75.7
	Domestic partnership/civil union	51	17.2
	Separated	4	1.3
	Divorced	2	0.7
	Widowed	2	0.7
	Single	11	3.7
	Prefer not to disclose	2	0.7
Ethnicity	White (British, Irish)	254	85.5
	White other	17	5.7
	Gypsy/Irish Traveller	1	0.3
	Mixed ethnicity	10	3.4
	Asian	8	2.7
	Black/African/Caribbean/Black British	1	0.3
	Prefer not to disclose	6	2.0

Introduction of solids

The mean age in weeks of babies introduced to solids was 23.5 (SD 3.5) and a range of 6-40 weeks, although the lower range was deemed to be an error on the part of the respondent, given that they stated they were following a baby–led approach and was removed from this calculation. In terms of first foods given, 77% (n = 226) offered a home-made food, while 23% (n = 68) used a commercially produced food. In terms of the form of the first food, 52% (n = 155) used a whole food, while 48% (n = 141) used a puree.

Overall, 72 (24.2%) participants self-identified as strict followers of BLW, 132 (44.4%) were using a loose form of BLW and 93 (31.3%) were not following the method and were classed as using "traditional weaning". To examine whether the behaviours of those identifying in each weaning group matched assumptions of that weaning group, participants were then asked to estimate to what degree their infant was spoon fed or self-fed. This was asked because in previous research, what individuals state they are doing, does not always match behaviour when analysed closely (Brown and Lee, 2011a).

One participant responded that their child was 100% spoon fed yet identified as strictly baby-led, as shown in table ten on the following page. On examining that respondent's script, it was determined that this person had checked the response incorrectly because on the next question they responded that their baby was being offered only finger foods, i.e. not being spoon fed by an adult. Table fourteen shows the breakdown of responses according to level of self-identified weaning group and (strict, loose, none) and level of spoon-feeding versus child-led feeding in reality. For table design, the remaining percentage refers to percentage of food self-fed.

Table 14: Self-identified weaning group and level of spoon versus child-led feeding

		100% spoon fed	**90% spoon fed**	**75% spoon fed**	**50% spoon fed**	**25% spoon fed**	**10% spoon fed**	**0% spoon fed**
Strict BLW	N	1	0	0	0	0	13	57
	%	1.4	0.0	0.0	0.0	0.0	18.3	80.3
Loose BLW	N	2	6	14	28	30	42	7
	%	1.6	4.6	10.9	21.7	23.2	32.6	5.4
Traditional	N	20	30	35	4	2	1	0
	%	21.7	32.6	38.0	4.3	2.2	1.1	0.0

Table fifteen presents the type of food offered by weaning group. As might be expected, none of those identifying as strict BLW offered pureed food or baby rice and all offered 90-100% finger food. Those in the loose BLW group offered a range of textures from purees (just 3 respondents) to 100% finger foods (33 participants). Interestingly in the traditional group, the largest group of respondents (n = 37, 40.2%) offered 90% purees with occasional finger foods but 2 participants offered 100% finger foods. For table design, the remaining percentage refers to percentage of food as purees.

Table 15: Self-identified weaning group and type of foods offered

		100% purees	**90% purees**	**75% purees**	**50% purees**	**25% purees**	**10% purees**	**0% purees**
Strict BLW	N	0	0	0	0	0	9	63
	%	0	0	0	0	0	12.5	87.5
Loose BLW	N	3	6	16	20	23	30	33
	%	2.3	4.6	12.2	15.3	17.6	22.9	25.2
Traditional	N	15	37	27	7	3	1	2
	%	16.3	40.2	29.3	7.6	3.3	1.1	2.2

Given that the results of the two questions regarding methods of feeding above generally reflected the weaning styles respondents had assigned themselves, it was decided that these self-assigned groupings were valid to use during the study.

Timing of introducing solids and weaning approach

Table sixteen shows timing of introduction of solid foods by each weaning group. The strict BLW group introduced solids later than the other two groups; infants in the strict BLW group had a mean age of 25.0 weeks, the loose BLW group 23.4 weeks and the traditional group 22.4 weeks.

Table 16: Age at first introduction of solid foods.

Weaning group	Mean age of baby at introduction in weeks	Range	Standard deviation
BLW – strict	25.04	19-32	1.74
BLW – loose	23.39	10-30	3.41
Traditional	22.43	12-40	4.24

A one-way ANOVA of timing between the three groups showed significant differences in the mean timing of solid food introduction between groups [F (2, 293) = 12.061, p = .000]. Post hoc Bonferroni tests showed significant differences between the strict BLW group and the loose BLW group (p = 0.003) and the strict and traditional groups (p < .001) but not the loose BLW and TW group (p = .115).

Milk feeding and weaning group

At birth, 252 of respondents were breast-feeding (84.8%), 37 were formula fed (12.5%) and 8 (2.7%) used expressed breast milk. This was significantly different between weaning groups according to a Chi Square analysis, which found that 69 (95.8%) of infants in the strict BLW were breast fed at birth, compared to 118 (89.4%) of those in the loose BLW group and 65 (69.9%) in the TW group, X^2 (4, 297) = 28.398, p = .000. At the time of the survey, 147 infants were breast fed (49.5%), 123 were formula fed (41.4%), 22 were combination fed (7.4%) and 5 (1.7%) used expressed breast milk. These rates were also significantly different between weaning groups as shown in table seventeen, X^2 (6, 297) = 81.598, p = .000.

Table 17: Milk feeding approach of weaning groups

	Milk feeding approach				
Weaning group	**Breast fed**	**Formula**	**Combination**	**Expressed breast milk**	**Total**
Strict BLW	59	9	3	1	72
Loose BLW	75	46	9	2	132
Traditional	13	68	10	2	93
Total	147	123	22	5	297

Parental demographic background and weaning group

The relationship between parental demographic background and weaning group was examined in a series of analyses. No significant difference was found in parental age or education level between weaning groups. However a difference was found for parity when examined with a Chi square analysis, with 43 parents (60%) in the strict BLW group having just one child, compared to 55% in the loose BLW group and 73% in the TW group, X^2 (2, 297) = 7.547, p = 0.023.

To answer research questions R2 (does food acceptance differ between weaning groups?), R4 (what are the differences in macro/micronutrient intake between groups?) and R5 (is BLW sufficient or significantly different to traditional weaning?), infant eating behaviour, food exposure, food frequency and enjoyment of specific foods were explored for the three weaning groups and three age groups separately.

Part one: Infants age 6 – 8 months old

This section presents the findings for infants age 6 – 8 months old (n = 144). Analyses controlled for parental age, parity, milk-feeding style at birth and age of introduction to solid food. In this age sub group, 24 infants were classed as strict BLW, 54 infants were classed as loose BLW and 66 were classed as using Traditional weaning.

1. **<u>Eating behaviour</u>**

Differences in infant eating behaviour, specifically enjoyment of eating, food fussiness, satiety responsiveness and food responsiveness were explored between the three weaning groups using a MANCOVA, shown in table eighteen. Parental age, parity, milk-feeding style at birth and timing of weaning were all controlled for as these differed significantly by weaning groups.

Table 18: Differences between weaning groups in Child Eating Behaviour in age group 1

	Strict BLW Mean (SD)	Loose BLW	Traditional	Significance
Satiety responsive	3.0 (.5)	2.8 (.6)	2.3 (.5)	F (2, 137) = 11.825 p = .000
Food responsive	2.1 (.5)	2.5 (1.0)	3.3 (.8)	F (2, 137) = 13.678, p = .000
Fussiness	1.5 (.4)	2.0 (.7)	2.8 (.6)	F (2, 137) = 33.764, p = .000
Enjoyment of eating	4.3 (.5)	4.0 (.6)	4.0 (.5)	F (2, 137) = 3.215 p = .043

Table shading denotes significance at p < 0.05

Post hoc Bonferroni tests identified significant differences between weaning groups. For satiety responsiveness, both BLW groups were rated as significantly more responsive than the traditional group (p = .000), but there was no significant difference between the BLW groups (p = .387). For food responsiveness, significant differences were found between the traditional group and each of the BLW groups (both p = .000), and between the two BLW groups (p = .020). For fussiness, differences were significant between all groups, and all reached significance of p = .000. However, for enjoyment of eating, the differences seen initially did not survive post hoc testing with the difference between the two BLW groups having a significance of p = .961 and the difference between both of the two BLW groups and the traditional group reaching p = 1.000.

2. **<u>Exposure to different foods</u>**

Again, parents indicated whether their child had ever been offered different food groups, shown in table nineteen. The association between ever having been offered a food (yes/no) and weaning group was explored using chi square. Significant differences between weaning groups that survived a Bonferroni correction for multiple tests (p = 0.001) are highlighted in dark grey. Those in light grey were initially significant at p = 0.05 but did not survive the correction for multiple tests.

Table 19: Exposure to different foods between weaning groups in age group 1

	Strict		**Loose**		**Traditional**		**Significance**	**Differences between groups**
	N	%	N	%	N	%		
Yoghurt	17	70.8	42	79.2	42	73.7	X^2 (2, 134) = .782, p = .676	
Processed meat	13	54.2	26	50.0	21	36.8	X^2 (2, 133) = 2.871, p = .238	
Meat substitutes	1	4.2	5	10.4	5	8.8	X^2 (2, 129) = .809, p = .667	
White fish	21	87.5	32	65.3	15	26.3	X^2 (2, 130) = 30.670, p = .000	Infants in the strict BLW group had a greater exposure compared to the loose BLW and traditional groups, p = .000
Oily fish	13	62.5	11	23.9	5	8.8	X^2 (2, 127) = 26.432 p = .000	Infants in the strict BLW group had a greater exposure compared to the loose BLW and traditional groups, p = .000
Roasted meat	21	87.5	35	72.9	16	28.1	X^2 (2, 129) = 33.254, p = .000	Infants in both BLW groups had a greater exposure than those in the traditional group, p = .000
Meat	18	79.2	38	79.2	44	77.2	X^2 (2, 129) = .073, p = .964	
Beans	16	66.7	26	54.2	13	22.8	X^2 (2, 129) = 17.440, p = .000	Infants in both BLW groups had a greater exposure compared to those in the traditional group, p = .000
Eggs	20	83.3	33	67.3	9	15.8	X^2 (2, 130) = 43.064, p = .000	Infants in both BLW groups had a greater exposure compared to those in the traditional group, p = .000

Fruit	24	100.0	49	100.0	57	100.0	N/A	
Citrus fruit	17	70.8	32	65.3	28	49.1	X^2 (2, 130) = 4.499, p = .105	
Tinned fruit	9	37.5	27	56.3	38	67.9	X^2 (2, 128) = 6.425, p = .040	Infants in the traditional group had a greater exposure than those in the two BLW groups, p = .040
Dried fruit	16	66.7	24	51.1	26	46.4	X^2 (2, 127) = 2.781, p = .249	
Vegetables	23	100.0	49	100.0	56	100.0	N/A	
Salad veg	19	79.2	39	79.6	41	73.2	X^2 (2, 129) = .693, p = .707	
Tinned veg	2	8.3	8	16.3	14	24.6	X^2 (2, 130) = 3.193, p = .203	
Rice cakes	20	83.3	39	79.6	46	80.7	X^2 (2, 130) = .145, p = .930	
Biscuits	11	45.8	10	20.4	34	59.6	X^2 (2, 130) = 16.773, p = .000	Infants in the traditional and strict BLW groups had a greater exposure than those in the loose BLW group, p = .000.
Crisps	8	33.3	11	22.4	28	50.0	X^2 (2, 129) = 8.688, p = .013	Infants in the traditional group had the greatest exposure compared to the two BLW groups, p = .013
Rusks	12	50.0	49	100.0	57	100.0	X^2 (2, 130) = 58.390, p = .000	100% of the traditional and loose BLW groups had eaten rusks compared to 50% of the strict BLW group, p = .000
Brown bread	21	87.5	37	77.1	34	59.6	X^2 (2, 129) = 7.647, p = .022	Infants in the strict BLW group had the greatest exposure compared to the loose BLW and traditional groups, p = .022.
White bread	12	50.0	29	59.2	49	86.0	X^2 (2, 130) = 13.982, p = .001	Infants in the traditional group had a greater exposure than those in the two BLW groups, p = .001
Chocolate	9	37.5	12	24.5	28	50.0	X^2 (2, 129) = 7.223, p = .027	Infants in the traditional group had the greatest exposure compared to the two BLW groups, p = .027

Other bread products	11	45.8	27	56.3	31	54.4	X^2 (2, 129) = .731, p = .694	
Cereals	18	75.0	30	62.5	43	75.4	X^2 (2, 129) = 2.381, p = .304	
Potatoes	23	95.8	44	91.7	49	86.0	X^2 (2, 129) = 2.073, p = .355	
Savoury biscuits	12	50.0	32	69.6	50	87.7	X^2 (2, 127) = 13.237, p = .001	Infants in the traditional group had the greatest exposure compared to the two BLW groups, p = .001
Baby crisps	4	16.7	25	52.1	38	66.7	X^2 (2, 129) = 16.915, p = .000	Infants in the traditional group had the greatest exposure compared to the two BLW groups (p = 000).
Baby cereals	2	8.3	16	33.3	50	87.7	X^2 (2, 129) = 54.218, p = .000	Infants in the traditional group had the greatest exposure compared to the two BLW groups (p = 000).
Baby biscuits	2	8.3	28	58.3	47	82.5	X^2 (2, 129) = 38.623, p = .000	Infants in the traditional group had the greatest exposure compared to the two BLW groups (p = 000).
Baby dried desserts	2	8.3	7	14.6	19	33.9	X^2 (2, 128) = 8.829, p = .012	Infants in the traditional group had the greatest exposure compared to the two BLW groups (p = 012)
Baby dried savoury meal	1	4.2	2	4.1	14	24.6	X^2 (2, 130) = 11.778, p = .003	Infants in the traditional group had the greatest exposure compared to the two BLW groups (p = 003)
Pizza	7	29.2	18	37.5	5	8.8	X^2 (2, 129) = 12.627, p = .002	Infants in the two BLW groups had higher exposure than those in the traditional group, (p = .002)
Chips	11	45.8	24	34.7	21	35.1	X^2 (2, 130) = 1.674, p = .433	
Cakes	11	45.8	17	32.7	20	35.0	X^2 (2, 130) = 1.005, p = .605	
Puddings	5	20.8	13	26.5	14	24.6	X^2 (2, 130) = .282, p = .869	
Marmite	2	8.3	5	10.4	28	50.0	X^2 (2, 128) = 25.757, p = .000	Infants in the traditional group had the greatest exposure compared to the two BLW groups (p = .000)

Sweet spreads	6	25.0	16	33.3	25	43.9	X^2 (2, 129) = 2.911, p = .233	
Added sugar	2	8.3	1	2.1	0	0.0	X^2 (2, 129) = 5.183, p = .075	
Spreads	11	45.8	34	72.3	32	56.1	X^2 (2, 128) = 5.349, p = .069	
Gravy	4	16.7	9	18.8	2	3.5	X^2 (2, 129) = 6.619, p = .037	Infants in the two BLW groups had higher exposure than those in the traditional group, (p = .037)

A Bonferroni corrected p-value of 0.001 denotes significance that has been corrected for multiple tests.

Table dark grey shading denotes significance at p < 0.001

Table light grey shading denotes significance at p < 0.05, which did not survive correction for multiple tests.

3. Food frequency

The results of the Food Frequency Questionnaire for this age group are shown in table twenty below. As before, "all" refers to both pureed and whole foods, while the second group of foods refer to those that can and are more likely to be self-fed, such as bread products. A MANCOVA identified significant differences for a number of food groups. Differences between weaning groups that survived a Bonferroni correction for multiple tests (p < 0.001) are highlighted in dark grey. Those in light grey were significant at p <0.05 but did not survive the correction for multiple tests.

Table 20: Food Frequency Questionnaire showing mean (SD) number of exposures in age group 1

	Strict	Loose	Traditiona l	Significance	Post-hoc differences between groups
All fresh fruit	8.0 (3.1)	7.2 (3.6)	7.3 (3.0)	F (2, 137) = .674 p = .511	
All vegetables	8.4 (3.5)	7.6 (5.2)	7.2 (3.8)	F (2, 137) = .712, p = .492	
All dried baby cereal	.5 (1.5)	1.6 (2.6)	4.0 (3.7)	F (2, 137) = 14.152, p = .000	There were differences between the TW group and both BLW groups (p = .000) but not the strict and loose BLW groups (p = .381).
All dried baby desserts	.0 (.0)	.1 (.5)	.9 (1.7)	F (2, 137) = 7.604, p = .001	There were differences between the TW and strict BLW group (p = .005) and the TW and loose BLW group (p = .002), but not the two BLW groups (p = 1.000).

All dried baby meals	.0 (.0)	.4 (1.5)	1.2 (2.2)	F (2, 137) = 4.233, p = .000	There were differences between the TW and strict BLW group (p = .016) and the TW and loose BLW group (p = .040), but not the two BLW groups (p = 1.000).
All yoghurt	4.9 (3.4)	5.4 (6.0)	6.2 (3.6)	F (2, 137) = .434, p = .649	
All processed meats	.6 (1.0)	.6 (1.5)	1.5 (1.7)	F (2, 137) = 2.925, p = .057	
All meat substitutes	.1 (.4)	.3 (.8)	.3 (1.1)	F (2, 137) = 1.095, p = .337	
All white fish	1.4 (.8)	1.7 (2.5)	.9 (2.3)	F (2, 137) = 1.838, p = .163	
All oily fish	.5 (.5)	.6 (1.5)	.2 (1.1)	F (2, 137) = 1.284, p = .280	
All roast/ grilled meat	3.2 (6.2)	2.1 (2.4)	1.0 (2.0)	F (2, 137) = 4.126, p = .018	There was a difference between the strict BLW and traditional groups, (p = .012) but not the two BLW groups (p = .461) or the loose BLW and TW group (p = .187).
All meat dishes	2.1 (1.6)	2.4 (2.6)	1.9 (3.5)	F (2, 137) = 1.215, p = .300	
All beans/ pulses	1.3 (2.5)	1.5 (2.2)	3.6 (4.3)	F (2, 137) = 5.085, p = .007	There were differences between the TW and strict BLW group (p = .010) and the TW and loose BLW group (p = .001), but not the two BLW groups (p = 1.000).
All tinned fruit	.1 (.3)	1.4 (2.8)	.4 (1.8)	F (2, 137) = 3.830, p = .024	There were differences between the loose and strict BLW groups (p = .045) and the loose BLW and TW groups (p = .032) but not the strict BLW and TW groups (p = 1.000).
All tinned vegetables	.0 (.0)	.2 (.8)	.3 (1.0)	F (2, 137) = 1.374, p = .256	
All cereals	1.6 (2.8)	2.0 (2.9)	1.9 (2.1)	F (2, 137) = .275, p = .760	
All potatoes	2.5 (2.2)	2.9 (2.7)	.9 (1.8)	F (2, 137) = 10.356, p = .000	There were differences between the TW and strict BLW group (p = .008) and the TW and loose BLW group (p < .001) but not the two BLW groups (p = 1.000).
All puddings/ ice cream	.3 (.8)	.5 (.9)	1.2 (1.9)	F (2, 137) = 3.696, p = .027	There were differences between the TW and strict BLW group (p = .028) and the TW and loose BLW group (p = .018) but not the two BLW groups (p = 1.000).
All added sugar	.4 (2.0)	.0 (.0)	.0 (.0)	F (2, 137) = 2.403, p = .094	

Citrus	2.5 (3.6)	1.0 (1.7)	.3 (1.0)	F (2, 137) = 11.383, p = .000	There were differences between the strict and loose BLW groups (p = .004) and between the strict BLW and TW groups (p < .001) but not the loose BLW and TW groups (p = 110).
Dried fruit	.5 (1.6)	1.2 (3.1)	.2 (.6)	F (2, 137) = 4.035, p = .020	There was a difference between the loose BLW and TW group (p = .018), but not the strict BLW and TW groups (p = 1.000) or the two BLW groups (p = .497).
Salad vegetables	3.4 (4.3)	2.3 (2.8)	.4 (1.5)	F (2, 137) = 7.000, p = .001	There were differences between the strict BLW and TW groups (p < .001) and the loose BLW and TW groups (p < .001) but not between the two BLW groups (p .319).
Cheese	2.4 (2.2)	1.9 (2.7)	.2 (.9)	F (2, 137) = 11.163, p = .000	There were differences between the TW and strict BLW group (p = .000) and the TW and loose BLW group (p = .000) but not the two BLW groups (p = .952).
Eggs	1.5 (1.6)	1.2 (1.5)	.1 (.2)	F (2, 137) = 19.280, p = .000	There were differences between the TW and strict BLW group (p < .001) and the TW and loose BLW group (p < .001) but not the two BLW groups (p .841).
Baby biscuits	.6 (1.1)	1.4 (2.1)	.9 (1.7)	F (2, 137) = 2.180, p = .117	
Baby crisps/crackers	.8 (1.6)	1.2 (1.8)	1.3 (1.8)	F (2, 137) = .613, p = .543	
Rusks	.3 (.4)	1.1 (2.0)	2.5 (2.5)	F (2, 137) = 8.430, p = .000	There were differences between the TW and strict BLW group (p = .000) and the TW and loose BLW group (p = .000) but not between the two BLW groups (p = .244).
Rice cakes	1.8 (2.8)	2.4 (2.7)	1.1 (1.8)	F (2, 137) = 5.698, p = .004	There was a difference between the loose BLW and TW group (p = .007) but not between the strict BLW and TW groups (p = .634) or the two BLW groups (p = .814).
Biscuits	.4 (.8)	.4 (1.0)	.6 (1.1)	F (2, 137) = .848, p = .431	
Crisps and savoury snacks	.2 (.6)	.6 (1.3)	.5 (1.2)	F (2, 137) = 1.085, p = .341	
Brown bread (incl wholemeal)	3.0 (2.6)	2.3 (2.7)	.6 (1.2)	F (2, 137) = 10.895, p = .000	There were differences between the TW and strict BLW group (p < .001) and the TW and loose BLW group (p < .001) but not the two BLW groups (p = .463).

White bread	.9 (1.7)	1.4 (2.1)	.5 (.9)	F (2, 137) = 2.292, p = .105	
Other bread products e.g. bagels, muffins	.3 (.7)	.6 (.9)	.2 (.8)	F (2, 137) = 3.610, p = .030	There was a difference between the traditional and loose BLW groups (p = .013), but not the TW and strict BLW groups (p = 1.000) or the two BLW groups (p = .146).
Chocolate and sweets	.0 (.2)	.1 (.5)	.1 (.4)	F (2, 137) = .670, p = .513	
Breakfast cereals	1.6 (2.8)	1.4 (2.4)	.2 (1.0)	F (2, 137) = 5.419, p = .005	There were differences between the TW and strict BLW group (p = .010) and the TW and loose BLW group (p = .003) but not the two BLW groups (p = 1.000).
Pizza	.3 (.4)	.2 (.6)	.1 (.3)	F (2, 137) = .928, p = .398	
Savoury biscuits and breadsticks	.4 (1.0)	.8 (1.3)	.4 (.9)	F (2, 137) = 1.615, p = .203	
Chips, roast potatoes and potato shapes	.1 (.3)	.4 (.8)	.0 (.1)	F (2, 137) = 7.197, p = .001	There were differences between the two BLW groups (p = .043) and the traditional and loose BLW groups (p < .001) but not the TW and strict BLW groups (p = 1.000).
Cakes (incl pancakes, fruit breads)	.4 (.5)	.2 (.6)	.2 (.5)	F (2, 137) = .844, p = .432	
Gravy and savoury sauces	.0 (.2)	.2 (.5)	.0 (.3)	F (2, 137) = 2.649, p = .074	
Marmite and Bovril	.1 (.4)	.2 (.7)	.0 (.2)	F (2, 137) = 3.130, p = .047	Differences did not survive post-hoc testing: between the strict BLW and TW group (p = 1.000), between the loose BLW and TW groups (p = .083) and between the two BLW groups (p = .690).
Sweet spreads	.7 (2.5)	.4 (1.1)	.0 (.2)	F (2, 137) = 2.497, p = .086	
Spreading fats (incl butter and margarine)	1.1 (1.8)	1.8 (2.5)	.6 (1.3)	F (2, 137) = 4.383, p = .014	There was a difference between the loose BLW and traditional groups (p = .002) but not between the strict BLW and TW groups (p= .814) or between the two BLW groups (p = .373).

A Bonferroni corrected p-value of 0.001 denotes significance that has been corrected for multiple tests.

Table dark grey shading denotes significance at $p < 0.001$

Table light grey shading denotes significance at $p < 0.05$*, which did not survive correction for multiple tests.*

4. **Perceived enjoyment**

Parents were also asked to rate how much their baby enjoyed the foods on a five-point scale, from 1 (dislikes a lot) to 5 (likes a lot), followed by an option to check a box if their baby had never tried the food in question. The results for parents who reported that their infant had tried a food and either liked it a little or a lot are reported below in table twenty one. Numbers of infants who expressed a preference are shown along with the percentage in each weaning group who had a positive reaction to the food. Significant associations are shown by a Fisher's Exact test, rather than a Chi Square test, due to the low numbers who had tried certain foods and the few infants who were perceived to dislike many foods. Significant differences between weaning groups highlighted in light grey shading were significant at p <0.05 but did not survive the correction for multiple tests.

Table 21: Food enjoyment by weaning group in age group 1

	Strict BLW		**Loose BLW**		**Traditional**		**Significance (Fisher's Exact Test)**	**Differences between groups**
	N	%	N	%	N	%		
Yoghurt	16	94.1	42	100	38	90.5	p = .141	
Processed meat	12	92.3	19	73.1	18	85.7	P = .193	
Meat substitutes	1	100.0	5	100.0	3	60.0	P = .545	
White fish	19	90.5	25	78.1	6	40.0	P = .009	Enjoyment was highest in the strict BLW group and lowest in the traditional group (p = .009)
Oily fish	15	100.0	8	72.7	2	40.0	P = .003	Enjoyment was highest in the strict BLW group at 100% and lowest in traditional group (p = .003)
Roasted meat	20	95.2	28	80.0	11	68.8	P = .185	
Meat dishes	19	100.0	35	92.1	33	75.0	P = .004	Enjoyment was highest in strict BLW group and lowest in traditional group (p = .004)
Beans	16	100.0	22	84.6	10	76.9	P = .056	
Eggs	19	95.0	24	72.7	5	55.6	P = .023	Enjoyment was highest in strict BLW group and lowest in traditional group (p = .023)

Fruit (non-citrus)	23	95.8	47	97.9	51	89.5	P = .345	
Citrus fruit	15	88.2	30	93.8	27	96.4	P = .360	
Tinned fruit	9	100.0	25	92.6	34	89.5	P = .788	
Dried fruit	16	93.8	24	91.7	26	73.1	P = .168	
Vegetables	22	95.7	38	77.6	33	58.9	P = .010	Enjoyment was highest in strict BLW group and lowest in traditional group (p = .010)
Salad veg	16	84.2	27	69.2	20	48.8	P = .051	
Tinned veg	2	100.0	6	75.0	11	78.6	P = 1.000	
Rice cakes	18	90.0	36	92.3	44	95.7	P = .726	
Biscuits	11	100.0	9	90.0	34	100.0	P = .182	
Crisps	8	100.0	11	100.0	28	100.0	N/A	
Rusks	12	100.0	44	89.8	57	100.0	P = .025	These were enjoyed by 100% of the strict BLW and traditional groups and 89.8% of the loose BLW group, p = .025
Brown bread	20	95.2	35	94.6	32	64.7	P = .004	Enjoyment was highest in the two BLW groups and lowest in the traditional group, (p = .004)
White bread	12	100.0	25	86.2	44	89.8	P = .338	
Chocolate	9	100.0	12	100.0	28	100.00	N/A	
Other bread products	11	100.0	26	96.3	29	93.5	P = 1.000	
Breakfast Cereals	17	94.4	23	76.7	39	90.7	P = .270	
Potatoes	21	91.3	31	70.5	38	77.6	P = .058	
Savoury biscuits	12	100.0	31	96.9	41	82.0	P = .073	
Baby crisps	4	100.0	23	92.0	36	94.7	P = .794	
Baby cereals/rice	2	100.0	11	68.8	43	86.0	P = .298	
Baby biscuits	2	100.0	25	89.3	44	93.6	P = .659	
Baby dried desserts	1	50.0	6	85.7	16	84.2	P = .372	
Baby dried meals	1	100.0	2	100.0	11	78.6	P = 1.000	
Pizza	7	100.0	16	88.9	5	100.0	P = .1.000	
Chips	10	90.9	19	79.2	16	76.2	P = .276	
Cakes	11	100.0	15	88.2	20	100.0	P = .530	
Puddings	4	80.0	12	92.3	14	100.0	P = .151	

Marmite	2	100.0	5	100.0	18	64.3	P = .722	
Added sugar	1	50.0	1	100.0	N/A	N/A	P = 1.000	
Sweet spreads	5	83.3	16	100.0	22	88.0	P = .433	
Butter/margarine	9	81.8	27	79.4	31	96.9	P = .077	
Gravy	4	100.0	9	100.0	2	100.0	N/A	

A Bonferroni corrected p-value of 0.001 denotes significance that has been corrected for multiple tests.

Table light grey shading denotes significance at p < 0.05, which did not survive correction for multiple tests.

<u>Part two: Infants age 9 – 10 months</u>

This section presents the findings for infants aged 9-10 months old (n = 77). As previously, parental age, parity, milk-feeding style at birth and age of introduction to solid food were controlled for. In this age sub group, 19 infants were classed as strict BLW, 44 infants were classed as loose BLW and 14 were classed as using traditional weaning.

1. **<u>Eating Behaviour</u>**

Differences in infant eating behaviour, specifically enjoyment of eating, food fussiness, satiety responsiveness and food responsiveness were explored between the three weaning groups using a MANCOVA, shown in table twenty-two. Parental age, parity, milk-feeding style at birth and timing of weaning were all controlled for as these differed significantly by weaning groups. Significant differences were found for two behaviours.

Table 22: Differences between weaning groups in Child Eating Behaviour in age group 2

	Strict BLW Mean (SD)	Loose BLW	Traditional	Significance
Satiety responsive	3.2 (.7)	2.8 (.7)	2.4 (.7)	F (2, 70) = 6.442, p = .003
Food responsive	2.2 (.7)	2.6 (1.0)	3.0 (1.0)	F (2, 70) = 1.885, p = .160
Fussiness	1.7 (.6)	1.7 (.6)	2.4 (.8)	F (2, 70) = 4.347, p = .017
Enjoyment of eating	4.1 (.6)	4.3 (.6)	4.4 (.6)	F (2, 70) = 1.194, p = .309

Table shading denotes significance at p < 0.05

In this age group, there were significant differences between groups for both satiety responsiveness and fussiness. For satiety responsiveness, the strict BLW group had the highest score and the traditional group the lowest (p = .003). For fussiness, the strict and loose BLW had the same scores of 1.7, while the traditional group had a higher fussiness rating of 2.4 (p = .017). When a post hoc Bonferroni test was used to examine the significant results, there was a significant difference between the traditional and strict BLW groups for satiety (p = .001), but not between the TW and loose BLW groups (p = .130) or between the two BLW groups (p = .059). For fussiness, there was a significant difference between the traditional and strict BLW groups (p = .023) and the traditional and loose BLW groups (p = .005), but not the two BLW groups (p = 1.000).

2. Exposure to different foods

Parents were asked whether their child and ever been given certain foods and if so, whether they enjoyed it. Whether or not infants in different weaning groups had ever tried certain foods is shown in table twenty three below, using a Chi Square analysis. Significant differences between weaning groups that survived a Bonferroni correction for multiple tests (p < 0.001) are highlighted in dark grey. Those in light grey shading were significant at p <0.05 but did not survive the correction for multiple tests.

Table 23: Exposure to different foods between weaning groups in age group 2

	Strict		Loose		Traditional		Significance	Differences between groups
	N	%	N	%	N	%		
Yoghurt	17	89.5	39	88.6	11	84.6	X^2 (2, 76) = .197, p = .906	
Processed meat	12	63.2	32	72.7	7	50.0	X^2 (2, 77) = 2.560, p = .278	
Meat substitutes	2	10.5	3	7.3	3	23.1	X^2 (2, 73) = 2.517, p = .284	
White fish	17	89.5	36	90.0	8	66.7	X^2 (2, 71) = 4.425, p = .109	
Oily fish	13	68.4	18	46.2	7	53.8	X^2 (2, 71) = 2.547, p = .280	

Roasted meat	17	89.5	37	86.0	11	84.6	X^2 (2, 75) = .191, p = .909	
Meat	14	73.7	37	86.0	10	76.9	X^2 (2, 75) = 1.528 p = .466	
Beans	17	89.5	31	72.1	8	61.5	X^2 (2, 75) = 3.537, p = .171	
Eggs	18	94.7	39	90.7	5	38.5	X^2 (2, 75) = 21.596, p = .000	Infants in both BLW groups had a greater exposure compared to the traditional group, p = .000
Fresh Fruit	19	100.0	43	100.0	13	100.0	N/A	
Citrus fruit	15	83.3	35	83.3	6	46.2	X^2 (2, 73) = 8.268, p = .016	Infants in both BLW groups had a greater exposure compared to the traditional group, p = .016
Tinned fruit	7	36.8	27	64.3	4	30.8	X^2 (2, 74) = 6.618, p = .037	Infants in the loose BLW group had a greater exposure than those in the strict BWL and traditional groups, p = .037
Dried fruit	8	42.1	25	61.0	9	69.2	X^2 (2, 73) = 2.778, p = .249	
Vegetables	19	100.0	41	100.0	13	100.0	N/A	
Salad veg	17	89.5	34	79.1	6	50.0	X^2 (2, 74) = 6.718, p = .035	Infants in both BLW groups had a greater exposure compared to the traditional group, p = .035
Tinned veg	4	21.1	8	18.6	4	30.8	X^2 (2, 75) = .881, p = .644	
Rice cakes	14	82.4	39	90.7	10	83.3	X^2 (2, 72) = 1.004, p = .605	
Biscuits	5	26.3	14	32.6	6	46.2	X^2 (2, 75) = 1.394, p = .498	
Crisps	4	21.1	17	39.5	6	46.2	X^2 (2, 75) = 2.647, p = .265	
Rusks	5	26.3	43	100.0	13	100.0	X^2 (2, 75) = 50.733, p = .000	100% of infants in the loose BLW and traditional groups had tried them, compared to 26% of the strict BLW group, p = .000.
Brown bread	16	84.2	34	81.0	9	75.0	X^2 (2, 73) = .404, p = .817	
White bread	11	57.9	34	79.1	10	76.9	X^2 (2, 75) = 3.125, p = .210	

Chocolate	7	36.8	17	39.5	3	23.1	X^2 (2, 75) = 1.181, p = .554	
Other bread products	13	68.4	31	73.8	7	53.8	X^2 (2, 74) = 1.850, p = .397	
Cereals	16	84.2	33	76.7	9	69.2	X^2 (2, 75) = 1.008, p = .604	
Potatoes	19	100.0	41	100.0	12	92.3	X^2 (2, 73) = 4.679, p = .096	
Savoury biscuits	13	68.4	34	82.9	8	61.5	X^2 (2, 73) = 3.093, p = .213	
Baby crisps	6	31.6	32	74.4	8	61.5	X^2 (2, 75) = 10.198, p = .006	Infants in the loose BLW group had a greater exposure than either the strict BLW and traditional groups, p = .006
Baby cereals	3	15.8	25	58.1	10	76.9	X^2 (2, 75) = 13.793, p = .001	Infants in the traditional group had a greater exposure than either BLW group, p = .001.
Baby biscuits	8	42.1	34	81.0	9	69.2	X^2 (2, 74) = 9.217, p = .010	Infants in the loose BLW group had a greater exposure than either the strict BLW and traditional groups, p = .010
Baby dried desserts	2	10.5	5	11.6	4	30.8	X^2 (2, 75) = 3,217, p = .195	
Baby dried savoury meals	2	10.7	2	4.7	4	30.8	X^2 (2, 75) = 7.147, p = .028	Infants in the traditional group had a greater exposure than those in both BLW groups, p = .028
Pizza	9	47.4	24	55.8	0	0.0	X^2 (2, 75) = 12.737, p = .002	Infants in both BLW groups had a greater exposure than those in the traditional group, which had zero exposure, p = .002.
Chips	10	52.6	31	72.1	7	53.8	X^2 (2, 75) = 2.870, p = .238	
Cakes	10	52.6	29	67.4	4	30.8	X^2 (2, 75) = 5.718, p = .057	
Puddings	4	22.2	21	48.8	4	30.8	X^2 (2, 74) = 4.241, p = .120	
Marmite	3	15.8	14	32.6	6	50.0	X^2 (2, 74) = 4.123, p = .127	
Sweet spreads	7	36.8	21	48.8	5	38.5	X^2 (2, 75) = .965, p = .617	

Added sugar	2	11.7	3	7.3	0	0.0	X^2 (2, 72) = 1.463, p = .481	
Spreads	11	57.9	37	86.0	6	46.2	X^2 (2, 75) = 10.391, p = .006	Infants in the loose BLW group had a greater exposure than those in either the strict BLW or traditional groups, p = .006.
Gravy	6	31.6	11	26.2	2	15.4	X^2 (2, 74) = 1.074, p = .584	

A Bonferroni corrected p-value of 0.001 denotes significance that has been corrected for multiple tests.

Table dark grey shading denotes significance at p < 0.001

Table light grey shading denotes significance at p < 0.05, which did not survive correction for multiple tests.

3. **Food frequency**

The results of the Food Frequency Questionnaire for this age group are shown in table twenty-four below. As before, "all" refers to both pureed and finger foods, while the second group of foods refer to those consumed in their whole form, which was unlikely to be pureed, such as bread products. Significant results of a MANCOVA carried out on the three groups are highlighted in grey; milk-feeding style, parity, maternal age and age of introduction to solids were controlled for as previously discussed. Differences between weaning groups that survived a Bonferroni correction for multiple tests (p < 0.001) are highlighted in dark grey. Those in light grey shading were significant at p <0.05 but did not survive the correction for multiple tests.

Table 24: Food Frequency Questionnaire showing mean (SD) number of exposures in age group 2

	Strict	Loose	Traditional	Significance	Differences between groups
All fresh fruit	10.7 (4.3)	7.8 (3.1)	9.9 (5.8)	F (2, 70) = 3.113 p = .051	
All vegetables	7.8 (5.1)	7.9 (4.3)	8.6 (4.3)	F (2, 70) = .611, p = .546	
All dry baby cereal	.5 (1.6)	2.5 (3.8)	4.7 (3.8)	F (2, 70) = 4,458, p = .015	There was a difference between the traditional and strict BLW group (p = .002) but not between the loose BLW and TW groups (p = .114) or the two BLW groups (p = .091).

All dried baby desserts	.0 (.0)	.2 (.9)	.6 (1.9)	F (2, 70) = 1.849, p = .165	
All dried baby meals	.0 (.0)	.4 (1.5)	.1 (.4)	F (2, 70) = .638, p = .531	
All yoghurt	4.1 (3.5)	7.4 (5.6)	6.2 (6.6)	F (2, 70) = 1.241, p = .295	
All processed meats	.9 (1.0)	1.6 (2.0)	2.1 (2.3)	F (2, 70) = .913, p = .406	
All meat substitutes	.2 (.5)	.3 (1.0)	.6 (1.9)	F (2, 70) = .784, p = .461	
All white fish	1.6 (1.2)	1.8 (2.6)	1.3 (2.2)	F (2, 70) = .137, p = .872	
All oily fish	.6 (.8)	.7 (1.6)	.5 (1.2)	F (2, 70) = .387, p = .681	
All roast/grilled meat	3.1 (2.8)	2.2 (2.0)	1.9 (2.9)	F (2, 70) = .808, p = .450	
All meat dishes	1.6 (1.3)	2.7 (2.9)	3.2 (3.7)	F (2, 70) = .735, p = .483	
All beans/pulses	2.3 (2.2)	2.4 (3.5)	4.3 (4.1)	F (2, 70) = 2.167, p = .122	
All tinned fruit	.1 (.2)	.6 (1.3)	.8 (2.1)	F (2, 70) = 1.444, p = .243	
All tinned vegetables	.2 (.5)	.5 (1.4)	0.0 (0.0)	F (2, 70) = .366, p = .695	
All cereals	3.2 (2.9)	2.2 (2.5)	2.1 (2.6)	F (2, 70) = 2.039, p = .138	
All potatoes	2.6 (1.8)	2.4 (3.0)	4.7 (5.7)	F (2, 70) = 5.112, p = .008	Differences did not survive post-hoc testing, where the differences reached a significance of p = .259 between the TW and strict BLW groups. For the loose and TW groups p = .091 and the two BLW groups, p = 1.000.
All puddings	.1 (.5)	.8 (1.2)	.9 (1.5)	F (2, 70) = 2.051, p = .136	
All added sugar	.1 (.2)	.0 (.0)	.0 (.0)	F (2, 70) = 1.141, p = .325	
Citrus	4.2 (3.8)	1.1 (1.4)	.8 (1.9)	F (2, 70) = 11.447, p = .000	There were differences between both BLW groups (p < .001) and the TW and strict BLW group (p < .001) but not the loose BLW and TW groups (p = 1.000).
Dried fruit	.6 (1.7)	.7 (1.2)	.4 (.6)	F (2, 70) = .123, p = .885	

Salad vegetables	4.2 (3.7)	2.7 (3.7)	1.2 (2.3)	F (2, 70) = 2.722, p = .073	
Cheese	3.1 (2.2)	3.3 (3.1)	1.8 (2.5)	F (2, 70) = 1.042, p = .358	
Eggs	1.9 (1.4)	1.5 (2.1)	.5 (.9)	F (2, 70) = 2.065, p = .134	
Baby biscuits	.8 (1.3)	1.6 (2.0)	.7 (1.4)	F (2, 70) = .885 p = .417	
Baby crisps/crackers	1.6 (2.0)	2.0 (2.8)	2.6 (3.9)	F (2, 70) = .603, p = .550	
Rusks	.8 (1.5)	1.3 (2.2)	1.1 (2.4)	F (2, 70) = .195, p = .823	
Rice cakes	2.6 (3.9)	2.8 (3.4)	3.6 (4.0)	F (2, 70) = .431, p = .652	
Biscuits	.1 (.5)	.9 (1.7)	.3 (.8)	F (2, 70) = .1.054, p = .354	
Crisps and savoury snacks	.2 (.7)	1.2 (1.8)	1.0 (3.7)	F (2, 70) = .887, p = .416	
Brown bread (incl wholemeal)	2.9 (2.5)	3.0 (3.2)	1.9 (2.6)	F (2, 70) = .353, p = .704	
White bread	1.5 (2.8)	2.3 (2.9)	.8 (1.6)	F (2, 70) = 1.737, p = .184	
Other bread products e.g. bagels, muffins	1.0 (1.5)	1.1 (2.0)	0.0 (0.0)	F (2, 70) = 2.540, p = .086	
Chocolate and sweets	0.0 (0.0)	.3 (.8)	0.0 (0.0)	F (2, 70) = 1.791, p = .174	
Breakfast cereals	3.2 (2.9)	1.8 (2.5)	.9 (2.2)	F (2, 70) = 3.463, p = .037	There was a difference between the traditional and strict BLW groups (p = .040) but not the loose BLW and TW groups (p = .783) or the two BLW groups (p = .154).
Pizza	.3 (.6)	.3 (.7)	.1 (.4)	F (2, 70) = .475, p = .624	
Savoury biscuits and breadsticks	1.6 (2.3)	1.1 (1.8)	1.8 (3.1)	F (2, 70) = .890, p = .415	
Chips, roast potatoes and potato shapes	.4 (.8)	.6 (1.0)	.1 (.3)	F (2, 70) = 1.255, p = .291	
Cakes (incl pancakes, fruit breads)	.8 (1.3)	.6 (1.0)	.1 (.3)	F (2, 70) = 2.374, p = .101	
Gravy and savoury sauces	.3 (.8)	.5 (1.4)	.2 (.8)	F (2, 70) = .586, p = .559	
Marmite and Bovril	.1 (.3)	.3 (.9)	.9 (2.2)	F (2, 70) = 2.464 p = .092	

Sweet spreads (incl peanut butter)	.6 (1.2)	.5 (1.2)	.4 (.9)	F (2, 70) = .283, p = .755	
Spreading fats (incl butter and margarine)	1.9 (2.5)	3.0 (3.6)	2.4 (4.6)	F (2,70) = .386. p = .681	

A Bonferroni corrected p-value of 0.001 denotes significance that has been corrected for multiple tests.

Table dark grey shading denotes significance at p < 0.001

Table light grey shading denotes significance at p < 0.05, which did not survive correction for multiple tests.

4. Perceived enjoyment

Parents were also asked to rate how much their baby enjoyed the foods on a five-point scale, from 1 (dislikes a lot) to 5 (likes a lot), followed by an option to check a box if their baby had never tried the food in question. The results for parents who reported that their infant had tried a food and either liked it a little or a lot are reported below in table twenty-five. Numbers of infants who expressed a preference are shown along with the percentage in each weaning group who had a positive reaction to the food. Significant associations are shown by a Fisher's Exact test, rather than a Chi Square test, due to the low numbers who had tried certain foods. Significant differences between weaning groups highlighted in dark grey diagonal shading were significant at p <0.05 but did not survive a correction for multiple tests.

Table 25: Food enjoyment by weaning group in age group 2

	Strict BLW		**Loose BLW**		**Traditional**		**Significance (Fisher's Exact Test)**	**Differences between groups**
	N	%	N	%	N	%		
Yoghurt	15	88.2	38	97.4	8	72.7	P = .021	Enjoyment was highest in the loose BLW group and lowest in the TW group (p = .021)
Processed meat	10	83.3	20	62.5	5	71.4	P = .790	
Meat substitutes	2	100.0	2	66.7	2	66.7	P = 1.000	
White fish	15	88.2	30	83.3	7	87.5	P = .840	
Oily fish	11	84.6	13	72.2	5	71.4	P = .338	

Roasted meat	16	94.1	30	88.1	8	72.7	P = .191	
Meat dishes	14	100.0	33	89.2	10	100.0	P = .464	
Beans	16	94.1	22	71.0	8	100.0	P = .302	
Eggs	12	66.7	25	64.1	5	100.0	P = .775	
Fruit (non-citrus)	19	100.0	41	95.3	11	84.6	P = .076	
Citrus fruit	13	86.7	33	94.3	5	83.3	P = .460	
Tinned fruit	6	85.7	24	88.9	4	100.0	P = .435	
Dried fruit	8	100.0	23	92.0	9	100.0	P = 1.000	
Vegetables	18	94.7	27	65.9	9	69.2	P = .179	
Salad veg	15	88.2	19	55.9	4	66.7	P = .102	
Tinned veg	4	100.0	7	87.5	3	75.0	P = .767	
Rice cakes	12	85.7	35	89.7	10	100.0	P = .356	
Biscuits	5	100.0	13	92.5	6	100.0	P = 1.000	
Crisps	3	75.0	15	88.2	6	100.0	P = .582	
Rusks	5	100.0	41	95.3	31	100.0	P = 1.000	
Brown bread	13	81.3	34	100.0	9	100.0	P = .020	100% of the loose BLW and TW groups expressed enjoyment compared to about 80% of the strict BLW group, p = .020
White bread	9	81.8	32	94.1	9	90.0	P = .367	
Chocolate	7	100.0	16	94.1	3	100.0	P = 1.000	
Other bread products	11	84.6	24	77.4	7	100.0	P = .808	
Breakfast Cereals	14	87.5	23	69.7	9	100.0	P = .486	
Potatoes	13	68.4	26	63.4	10	83.3	P = .045	Enjoyment was highest in the traditional group compared with both BLW groups, p = .045.
Savoury biscuits	12	92.3	32	94.1	7	87.5	P = .772	
Baby crisps	6	100.0	32	100.0	8	100.0	N/A	
Baby cereals/rice	2	66.7	14	56.0	8	88.0	P = .726	
Baby biscuits	8	100.0	31	91.2	9	100.0	P = 1.000	
Baby dried desserts	2	100.0	5	100.0	4	100.0	P = N/A	
Baby dried meals	1	50.0	1	50.0	2	50.0	P = .771	

Pizza	6	66.7	20	83.3	0	0	P = .081	
Chips	7	70.0	25	80.6	6	85.7	P = .879	
Cakes	8	80.0	26	89.7	4	100.0	P = .753	
Puddings	4	100.0	19	90.5	4	100.0	P = 1.000	
Marmite	3	100.0	8	57.1	4	66.7	P = .757	
Added sugar	2	100.0	3	100.0	0	0	N/A	
Sweet spreads	6	85.7	18	85.7	5	100.0	P = .854	
Butter/margarine	9	81.8	27	79.4	31	96.9	P = .077	
Gravy	6	100.0	9	81.8	2	100.0	P = 1.000	

A Bonferroni corrected p-value of 0.001 denotes significance that has been corrected for multiple tests. Table light grey shading denotes significance at p < 0.05, which did not survive correction for multiple tests.

Part three: Infants aged 11 – 12 months

Next, infant eating behaviour and food exposure was explored for the three weaning groups separately. This section presents the findings for infants age 11-12 months old (n = 75). As previously, analyses control for parental age, parity, milk-feeding style at birth and age of introduction to solid food. In this age sub group, 28 infants were classed as strict BLW, 34 infants were classed as loose BLW and 13 were classed as using Traditional weaning.

1. **Eating Behaviour**

Differences in infant eating behaviour, specifically enjoyment of eating, food fussiness, satiety responsiveness and food responsiveness were explored between the three weaning groups using a MANCOVA, shown in table twenty-six. Parental age, parity, milk-feeding style at birth and timing of weaning were all controlled for as these differed significantly by weaning groups. Significant differences were found for just one behaviour, satiety responsiveness, shown in light grey shading representing a significance of p < .05.

Table 26: Differences between weaning groups in Child Eating Behaviour in age group 3

	Strict BLW	Loose BLW	Traditional	P
Satiety responsive	2.7 (.7)	2.9 (.5)	2.3 (.7)	F (2, 68) = 3.730, p = .029
Food responsive	2.4 (1.0)	2.6 (.6)	3.1 (.9)	F (2, 68) = 2.784, p = .069
Fussiness	1.8 (.7)	2.0 (.7)	1.8 (.6)	F (2, 68) = .814, p = .447
Enjoyment of eating	4.1 (.8)	4.0 (.7)	4.3 (.6)	F (2, 68) = 1.667, p = .195

Table shading denotes significance at p < 0.05

There was a significant difference between groups for satiety responsiveness score, with the loose BLW appearing to be most responsive and the traditional group having the lowest score. A post-hoc Bonferroni test found a significant difference between traditional and loose BLW groups, p = .024 but not the strict BLW and TW groups (p = .222) or the two BLW groups (p = .835).

2. **Exposure to different foods**

Parents were asked whether their child and ever been given certain foods and if so, whether they enjoyed it. Whether or not infants in different weaning groups had ever tried certain foods is shown in table twenty-seven below, using a Chi Square analysis. Significant differences between weaning groups that survived a Bonferroni correction for multiple tests (p < 0.001) are highlighted in dark grey. Those in light grey shading were significant at p <0.05 but did not survive correction for multiple tests.

Table 27: Exposure to different foods between weaning groups in age group 3

	Strict		Loose		Traditional		Significance	Differences between groups
	N	%	N	%	N	%		
Yoghurt	23	82.1	32	97.0	12	92.3	X^2 (2, 74) = 3.946, p = .139	
Processed meat	19	67.9	20	64.5	7	53.8	X^2 (2, 72) = .765, p = .682	
Meat substitutes	3	12.0	1	3.4	0	0.0	X^2 (2, 67) = 2.773, p = .250	
White fish	26	92.9	30	93.8	12	92.3	X^2 (2, 73) = .036, p = .982	
Oily fish	21	75.0	15	46.9	8	61.5	X^2 (2, 73) = 4.944, p = .084	
Roasted meat	26	92.9	26	81.3	12	92.3	X^2 (2, 73) = 2.176, p = .337	
Meat	24	85.7	28	87.5	11	84.6	X^2 (2, 73) = .078, p = .962	
Beans	26	92.9	30	93.8	11	84.6	X^2 (2, 73) = 1.092, p = .579	
Eggs	27	96.4	32	100.0	11	84.6	X^2 (2, 73) = 5.586, p = .061	
Fruit	28	100.0	32	100.0	13	100.0	N/A	
Citrus fruit	25	89.3	26	81.3	4	30.8	X^2 (2, 73) = 17.434, p = .000	Infants in both BLW groups had a greater exposure compared to the traditional group, p = .000
Tinned fruit	15	53.6	16	50.0	7	53.8	X^2 (2, 73) = .097, p = .953	
Dried fruit	21	75.0	24	75.0	9	81.8	X^2 (2, 71) = .237, p = .888	
Vegetables	28	100.0	32	100.0	13	100.0	N/A	
Salad veg	26	92.9	27	84.4	9	75.0	X^2 (2, 72) = 2.385, p = .303	
Tinned veg	6	21.4	7	21.9	7	58.3	X^2 (2, 72) = 6.703, p = .035	Infants in the traditional group had a greater exposure than the two BLW groups, p = .035.
Rice cakes	25	89.3	31	96.9	13	100.0	X^2 (2, 73) = 2.578, p = .276	
Biscuits	17	60.7	20	64.5	9	69.2	X^2 (2, 72) = .288, p = .866	
Crisps	12	42.9	14	43.8	5	38.5	X^2 (2, 73) = .109, p = .947	

Rusks	8	28.6	32	100.0	13	100.0	X^2 (2, 73) = 44.272, p = .000	100% of infants in the loose BLW and traditional groups had been exposed compared to 29% of the strict BLW group, p = .000.
Brown bread	25	89.3	27	87.1	10	83.8	X^2 (2, 71) = .271, p = .873	
White bread	19	67.9	27	87.1	11	84.6	X^2 (2, 72) = 3.587, p = .166	
Chocolate	10	35.7	15	48.4	4	33.3	X^2 (2, 71) = 1.315, p = .518	
Other bread products	24	85.7	26	81.3	8	66.7	X^2 (2, 72) = 1.963, p = .375	
Cereals	25	89.3	29	90.6	11	84.6	X^2 (2, 73) = .345, p= .842	
Potatoes	28	100.0	31	96.9	13	100.0	X^2 (2, 73) = 1.299, p = .522	
Savoury biscuits	19	67.9	26	81.3	11	84.6	X^2 (2, 73) = 2.052, p = .358	
Baby crisps	15	55.6	24	77.4	11	84.6	X^2 (2, 71) = 4.851, p = .088	
Baby cereals	5	17.9	14	45.2	11	84.6	X^2 (2, 72) = 16.552, p = .000	Infants in the traditional group had a greater exposure than the two BLW groups, p = .000. Less than 20% of the strict BLW group had tried baby cereals.
Baby biscuits	12	42.9	22	68.8	11	84.6	X^2 (2, 73) = 7.764, p = .021	Infants in the traditional group had a greater exposure than the two BLW groups, p = .021.
Baby dried desserts	2	7.1	3	9.4	2	15.4	X^2 (2, 73) = .699, p = .705	
Baby dried savoury meals	3	10.7	1	3.1	2	15.4	X^2 (2, 73) = 2.217, p = .330	
Pizza	17	60.7	19	59.4	2	15.4	X^2 (2, 73) = 8.533, p = .014	Infants in the two BLW groups had a greater exposure than the traditional group, p = .014.
Chips	19	67.9	25	78.1	6	46.2	X^2 (2, 73) = 4.387, p = .112	

Cakes	17	60.7	23	71.9	3	23.1	X^2 (2, 73) = 9.155, p =.010	Infants in the loose BLW groups had a greater exposure than the traditional group, p = .010
Puddings	8	28.6	16	50.0	1	7.7	X^2 (2, 73) = 7.998, p = .018	Infants in the loose BLW group had a greater exposure than the strict BLW and traditional groups, p = .018.
Marmite	5	17.9	16	50.0	5	38.5	X^2 (2, 73) = 6.784, p = .034	Infants in the loose BLW group had a greater exposure than those in the strict BLW and traditional groups, p = .034
Sweet spreads	20	71.4	13	41.9	6	46.2	X^2 (2, 72) = 5.565, p = .062	
Added sugar	2	7.1	4	12.5	2	15.4	X^2 (2, 73) = .757, p = .685	
Spreads	18	64.3	27	84.4	11	84.6	X^2 (2, 73) = 3.927, p = .140	
Gravy	13	46.4	9	29.0	3	23.1	X^2 (2, 72) = .2.913, p = .233	

A Bonferroni corrected p-value of 0.001 denotes significance that has been corrected for multiple tests.

Table dark grey shading denotes significance at p < 0.001

Table light grey shading denotes significance at p < 0.05, which did not survive correction for multiple tests.

3. **Food frequency**

The results of the Food Frequency Questionnaire for this age group are shown in table twenty-eight below. As before, “all” refers to both pureed and finger foods, while the second group of foods refer to those consumed in their whole form, which was unlikely to be pureed, such as bread products. Significant results of a one-way MANCOVA carried out on the three groups are highlighted in grey; milk-feeding style, parity, maternal age and age of introduction to solids were controlled for as previously discussed. Significant differences between weaning groups that survived a Bonferroni correction for multiple tests ($p < 0.001$) are highlighted in dark grey. Those in light grey shading were significant at $p <0.05$ but did not survive the correction for multiple tests.

Table 28: Food Frequency Questionnaire showing mean (SD) number of exposures in age group 3

	Strict Mean	**Loose**	**Traditional**	**Significance**	**Differences between groups**
All fresh fruit	9.7 (4.8)	8.4 (3.6)	10.8 (3.1)	F (2, 68) = .878, p = .420	
All vegetables	11.1 (6.6)	8.7 (3.4)	11.0 (3.4)	F (2, 68) = 2.564, p = .084	
All dry baby cereal	.8 (2.0)	1.1 (2.2)	3.8 (4.0)	F (2, 68) = 6.126, p = .004	There were differences between the traditional and strict BLW groups (p = .002) and traditional and loose BLW groups (p = .005) but not the two BLW groups (p = 1.000).
All dried baby desserts	.1 (.3)	.1 (.2)	.4 (1.0)	F (2, 68) = 1.510, p = .228	
All dried baby meals	.0 (.0)	.2 (1.2)	.4 (1.4)	F (2, 68) = .630, p = .536	
All yoghurt	2.9 (2.5)	6.4 (6.2)	7.4 (2.4)	F (2, 68) = 6.372, p = .003	There were differences between the two BLW groups (p = .009) and the TW and strict BLW group (p = .013) but not the TW and loose BLW groups (p = 1.000).
All processed meats	1.0 (1.1)	1.1 (1.3)	1.2 (1.1)	F (2, 68) = .189, p = .829	
All meat substitutes	.2 (.7)	.4 (.9)	.5 (1.0)	F (2, 68) = .538, p = .587	
All white fish	1.8 (1.3)	1.7 (1.9)	2.5 (2.2)	F (2, 68) = .674, p = .513	
All oily fish	.5 (.7)	.8 (1.5)	.5 (1.0)	F (2, 68) = 1.098, p = .339	
All roast/grilled meat	3.0 (3.4)	1.5 (1.5)	2.9 (3.6)	F (2, 68) = 2.242, p = .114	
All meat dishes	2.2 (2.3)	3.0 (3.0)	3.2 (2.4)	F (2, 68) = 1.077, p = .346	
All beans/pulses	2.5 (2.2)	3.2 (3.1)	2.1 (2.2)	F (2, 68) = .882, p = .419	
All tinned fruit	.5 (1.2)	.6 (1.5)	.3 (.9)	F (2, 68) = .392, p = .677	
All tinned vegetables	.3 (.8)	.4 (1.0)	.2 (.8)	F (2, 68) = .194, p = .824	
All cereals	2.3 (2.6)	3.7 (3.6)	3.8 (3.0)	F (2, 68) = 1.793, p = .174	
All potatoes	2.6 (1.6)	3.5 (2.3)	3.8 (2.9)	F (2, 68) = 1.944, p = .151	

All puddings	.2 (.6)	.3 (1.0)	.7 (1.4)	F (2, 68) = .775, p = .465	
All added sugar	.0 (.0)	.2 (.9)	.0 (.0)	F (2, 68) = 1.168, p = .317	
Citrus	3.8 (4.3)	1.8 (2.1)	.7 (1.2)	F (2, 68) = 6.648, p = .002	There were differences between both BLW groups (p = .042) and the TW and strict BLW group (p = .011) but not the TW and loose BLW groups (p = .780).
Dried fruit	1.2 (2.1)	2.1 (2.8)	.3 (.8)	F (2, 68) = 1.433, p = .246	
Salad vegetables	2.8 (3.3)	3.0 (3.2)	2.5 (4.3)	F (2, 68) = .244, p = .784	
Cheese	3.2 (2.7)	3.5 (3.1)	3.2 (3.1)	F (2, 68) = .308, p = .736	
Eggs	2.5 (1.8)	1.3 (1.4)	.6 (.7)	F (2, 68) = 19.280, p = .000	There were differences between the strict BLW groups and traditional groups (p < .001) and the two BLW groups (p = .005) but not TW and loose BLW groups (p = .424).
Baby biscuits	.9 (1.8)	2.9 (3.2)	1.8 (2.3)	F (2, 68) = 4.583, p = .014	There was a difference between the two BLW groups (p = .012) but not the TW and strict BLW groups (p = 1.000) or the TW and loose BLW groups (p = .557).
Baby crisps/crackers	1.7 (3.1)	2.8 (2.8)	3.0 (2.5)	F (2, 68) = 1.877, p = .161	
Rusks	.5 (.9)	.4 (1.1)	.1 (.3)	F (2, 68) = .799, p = .454	
Rice cakes	1.3 (1.9)	2.6 (3.1)	4.1 (3.1)	F (2, 68) = 4.651, p = .013	There was a difference between the traditional and strict BLW groups (p = .008) but not the loose BLW and TW groups (p = .322) or the two BLW groups (p = .153).
Biscuits	.3 (.6)	.9 (1.6)	.2 (.6)	F (2, 68) = 2.638, p = .079	
Crisps and savoury snacks	.6 (1.7)	1.0 (1.4)	.8 (1.4)	F (2, 68) = .234, p = .792	
Brown bread (incl wholemeal)	3.3 (2.5)	3.6 (3.5)	3,2 (3.4)	F (2, 68) = .014, p = .986	
White bread	.9 (2.1)	1.6 (2.4)	2.0 (2.2)	F (2, 68) = 1.179, p = .314	
Other bread products e.g. bagels, muffins	.9 (1.3)	.8 (1.3)	.2 (.6)	F (2, 68) = 1.367, p = .262	

Chocolate and sweets	.2 (.8)	.5 (1.0)	.2 (.6)	F (2, 68) = .835, p = .438	
Breakfast cereals	2.1 (2.5)	3.3 (3.0)	2.5 (3.1)	F (2, 68) = 1.160, p = .112	
Pizza	.3 (.6)	.4 (.6)	.0 (.0)	F (2, 68) = 2.518, p = .088	
Savoury biscuits and breadsticks	.8 (1.5)	1.7 (2.2)	1.0 (1.4)	F (2, 68) = 2.241, p = .114	
Chips, roast potatoes and potato shapes	.6 (.7)	.6 (.9)	.0 (.0)	F (2, 68) = 3.371, p = .040	There was a difference between the traditional and loose BLW groups (p = .036) but not the TW and strict BLW groups (p = .070) or the two BLW groups (p = 1.000).
Cakes (incl pancakes, fruit breads)	.5 (.9)	.9 (1.2)	.2 (.6)	F (2, 68) = 2.712, p = .074	
Gravy and savoury sauces	.6 (1.1)	.4 (1.0)	.0 (.0)	F (2, 68) = 1.437, p = .245	
Marmite and Bovril	.2 (.5)	.8 (1.8)	.8 (2.0)	F (2, 68) = 1.712, p = .188	
Sweet spreads (incl peanut butter)	1.0 (1.4)	.4 (1.3)	.4 (.9)	F (2, 68) = 1.920, p = .154	
Spreading fats (incl butter and margarine)	2.6 (3.5)	3.8 (4.4)	3.4 (2.8)	F (2, 68) = .337, p = .715	

A Bonferroni corrected p-value of 0.001 denotes significance that has been corrected for multiple tests.

Table dark grey shading denotes significance at p < 0.001

Table light grey shading denotes significance at p < 0.05, which did not survive correction for multiple tests.

4. **Perceived enjoyment**

Parents were also asked to rate how much their baby enjoyed the foods on a five-point scale, from 1 (dislikes a lot) to 5 (likes a lot), followed by an option to check a box if their baby had never tried the food in question. The results for parents who reported that their infant had tried a food and either liked it a little or a lot are reported below in table twenty nine. Numbers of infants who expressed a preference are shown along with the percentage in each weaning group who had a positive reaction to the food. Significant associations are shown by a Fisher's Exact test, rather than a Chi Square test, due to the low numbers who had tried certain foods. Significant differences between weaning groups highlighted in light grey shading were significant at p <0.05 but did not survive the correction for multiple tests.

Table 29: Food enjoyment by weaning group in age group 3

	Strict BLW		Loose BLW		Traditional		Significance (Fisher's Exact Test)	Difference between groups
	N	%	N	%	N	%		
Yoghurt	21	91.4	31	96.9	12	100.0	P = .841	
Processed meat	15	78.9	17	85.0	5	71.4	P = .519	
Meat substitutes	3	100.0	1	100.0			N/A	
White fish	23	88.5	24	80.0	11	91.7	P = .887	
Oily fish	18	85.7	13	86.7	7	87.5	P = .217	
Roasted meat	22	84.6	18	69.2	11	91.7	P = .372	
Meat dishes	23	95.8	25	89.3	10	90.9	P = .712	
Beans	23	88.5	24	80.0	9	81.8	P = .642	
Eggs	20	74.1	22	68.8	7	63.6	P = .818	
Fruit (non-citrus)	27	96.4	30	96.8	12	92.3	P = .442	
Citrus fruit	23	92.0	21	84.0	4	100.0	P = .877	
Tinned fruit	13	86.7	16	100.0	4	57.1	P = .005	Enjoyment was highest in the loose BLW group compared to the traditional group (p = .005)
Dried fruit	20	95.2	21	87.5	9	100.0	P = 1.000	
Vegetables	25	89.3	22	68.8	10	76.9	P = .201	
Salad veg	22	84.6	20	74.1	6	66.7	P = .309	
Tinned veg	5	83.3	7	100.0	5	71.4	P = .484	
Rice cakes	25	100.0	26	83.9	13	100.0	P = .147	
Biscuits	14	82.4	18	90.0	7	77.8	P = .426	
Crisps	12	100.0	14	100.0	4	80.0	P = .161	
Rusks	6	75.0	31	96.9	11	84.6	P = .106	
Brown bread	25	100.0	26	96.3	9	90.0	P = .299	
White bread	18	94.7	23	85.2	11	100.0	P = .841	
Chocolate	10	100.0	13	86.9	4	100.0	P = .631	
Other bread products	24	100.0	23	88.5	8	100.0	P = .676	
Breakfast Cereals	24	96.0	25	86.2	11	100.0	P = .496	
Potatoes	25	89.3	20	64.5	11	84.6	P = .157	
Savoury biscuits	16	84.2	22	84.6	10	90.9	P = 1.000	

Baby crisps	15	100.0	22	91.7	9	81.8	P = .242	
Baby cereals/rice	5	100.0	9	64.3	9	81.8	P = .666	
Baby biscuits	12	100.0	20	90.9	9	81.8	P = .363	
Baby dried desserts	2	100.0	2	66.7	2	100.0	P = 1.000	
Baby dried meals	1	33.3	1	100.0	1	50.0	P = .800	
Pizza	16	94.1	17	89.5	2	100.0	P = .1.000	
Chips	17	89.5	20	80.0	5	83.3	P = .826	
Cakes	14	82.4	20	87.0	3	100.0	P = .868	
Puddings	8	100.0	15	93.8	1	100.0	P = 1.000	
Marmite	3	60.0	11	68.8	5	100.0	P = .402	
Added sugar	1	50.0	1	25.0	2	100.0	P = .657	
Sweet spreads	20	100.0	10	76.9	3	50.0	P = .005	Enjoyment was highest in the strict BLW group (100%) compared to 50% of the traditional group (p = .005)
Butter/ margarine	12	66.7	23	85.2	10	90.9	P = .248	
Gravy	10	76.9	6	66.7	3	100.0	P = .680	

A Bonferroni corrected p-value of 0.001 denotes significance that has been corrected for multiple tests.

Table light grey shading denotes significance at p < 0.05, which did not survive correction for multiple tests.

Discussion

The aim of this study was to compare differences in perceived eating behaviour and enjoyment and exposure to different food groups between babies following a strict BLW, loose BLW or traditional weaning approach, including how any differences may change over time as infants move through the weaning process. Overall a number of differences emerged between the groups, but these changed over time particularly in relation to exposure to different food groups.

Starting with eating behaviour, significant differences were perceived between weaning groups. Across all age groups infants following a BLW approach were perceived as more satiety responsive than those following a traditional approach. Likewise, for infants 6 – 8 months old, those following a BLW approach were seen as less food responsive, although this didn't hold for infants aged 9 – 10 or 11 – 12 months, when there was no difference between groups. Although this study was not longitudinal, it appeared that BLW infants became slightly more food responsive and TW infants slightly less over time.

As previously discussed, evidence exploring satiety responsiveness in infants has been mixed. One UK study found that infants following a BLW approach were more satiety responsive (and less food responsive) aged 12-24 months than those weaned traditionally (Brown and Lee, 2015). However the BLISS research project in New Zealand found that infants using a modified form of BLW was less satiety responsive than a control group of weaned using traditional methods (Taylor et al., 2017). In addition, a recent UK study comparing infants using different levels of self-feeding, found no difference in satiety responsiveness between groups (Komninou et al., 2019). Despite this, several qualitative studies have suggested that parents using BLW believe their infants are able to recognise internal satiety cues better than if they had been spoon-fed (Arden and Abbott, 2014; Brown and Lee, 2013; Cameron et al., 2012a).

It is possible that there is an element of wishful thinking on behalf of parents with regard to the effects of BLW on toddlers' behaviours. Perhaps those completing a survey with questions on satiety may report that their child acts in a way they would like their child to act. But on the other hand, for many parents it may be preferable to say that their child is a "good eater", because a big baby may be seen as a healthy, thriving baby (Baughcum et al., 2001; Redsell et al., 2010). It is also possible that the limitations of the BLISS study (i.e. offering high energy foods daily) may have affected satiety responsiveness.

However, there are also logical explanations for why BLW may genuinely show a greater level of satiety responsiveness. It is possible that spoon-feeding encourages infants to ignore internal hunger cues if parents feed in a non-responsive way, for example, encouraging babies to have "just one more" spoonful when they are showing signs of being full by turning their head away. In previous research using an internet survey of 702 mothers comparing TW and BLW, it was found that those using TW exerted greater pressure to eat (Brown and Lee, 2011c), which may disrupt normal appetite cues and is in fact associated with lower weight, although the direction of influence is unclear and may be bi-directional (Farrow and Blissett, 2008; Mitchell, Farrow, Haycraft, & Meyer, 2013; Sparks and Radnitz, 2013).

In terms of fussy eating, although BLW infants were perceived as less fussy in younger age groups; no significant difference was seen in fussy eating for babies aged 11 – 12 months. Lower fussiness has been observed in other studies on BLW as outlined in the review of literature found in chapter one (Brown and Lee, 2015; Fu et al., 2018). There are a number of potential explanations for this including as noted previously lower levels of control in mothers using BLW, as high levels of control have previously been associated with fussiness (Faith et al., 2004; Morrison, Power, Nicklas, & Hughes, 2013).

It is also possible that foods in their whole form are more appealing to infants. It is notable that no differences in fussiness were present at 11 – 12 months, with the scores for the strict BLW groups rising slightly over the three age points from a score of 1.5 at 6-8 months to 1.8 at 11-12 months, while the scores for the TW group dropped from 2.8 to 1.8, suggesting that changes in fussiness might be greater in infants being spoon-fed. Could this be because all infants would be expected to eat fewer pureed foods at this age? Modified texture diets used in adults with dysphagia have poor compliance, partly due to lack of enjoyment in those for whom purees are prescribed (Sura, Madhavan, Carnaby, & Crary, 2012; Vucea et al., 2018). One qualitative study of consumer and family members of those eating a pureed diet, found none of the interviewees enjoyed their food, the products were unappealing and foods were often indistinguishable from each other (Keller and Duizer, 2014), and it is possible that infants and children eating pureed foods feel similarly. Longitudinal research is clearly needed to explore changes in eating behaviour within infants over time, particularly those weaned using BLW.

It is possible that infant temperament could play a role in perceptions of fussiness and that parents with infants who are more adventurous are more likely to let them follow BLW. However, babies in the BLISS randomised controlled trial who were following BLW were also rated as less fussy compared to their standard weaned peers and clearly infant personality was not taken into account when weaning groups were randomly assigned (Taylor et al., 2017).

Fussiness also fits closely with concepts of enjoyment of food, and there is some evidence that potential drivers of fussiness, such as parental behaviour, contrast with those seen when children display enjoyment of food (Finnane et al., 2017; Jansen, Mallan, Nicholson,

& Daniels, 2014) and therefore children seen as fussy, may not be viewed as enjoying their food. BLW infants were perceived to enjoy food more, particularly in the younger age group at the start of weaning. They were also rated as enjoying a wider variety of food. Again, it may be that eating whole foods, rather than purees, is more enjoyable. They can certainly be played with and explored more easily than purees, and this is an important way in which babies can learn about their environment. Babies who first experience foods in their whole form, such as a wedge of sweet potato or a pasta shape, learn to associate those foods with a particular taste, rather than the vaguely similar sweetness of purees, many of which are based on apple puree. They may also be able to learn earlier about how different foods make them feel, whereas purees can be fairly homogenous in taste and calorie density, since many are bulked out with starches or water.

It could also be the case that infants introduced to a variety of textures earlier, are more likely to be accepting of a range of foods and their parents may observe this acceptance as enjoyment: there is evidence that familiarity with different foods promotes enjoyment of that food, so perceived enjoyment might be linked with acceptance due to increased familiarity (Blossfeld, Collins, Kiely, & Delahunty, 2007; Nicklaus, 2016; Werthmann et al., 2015). Research has also highlighted increased fruit and vegetable acceptance in older children who have been encouraged to "play" with their food, suggesting that multi-sensory exposure to different foods promotes their acceptance (Coulthard and Ahmed, 2017). Infants given food to handle and manipulate may be more likely to try them – and at their own pace.

Alternatively, meal times have been found to be more relaxed when using BLW (Brown and Lee, 2013; Cameron et al., 2012a), so that it could appear to parents that their children are enjoying their food more. As previously discussed, mothers using BLW have been found to be more relaxed about weaning and less anxious (Brown, 2015; Brown and Lee, 2011a, 2011c), which could mean they perceive their baby to be happier and enjoying their food more. In addition, it could be that the act of eating as a family, which is encouraged in BLW, is genuinely more enjoyable for both the child and the parents.

The question arises as to whether this is a valid measurement in younger infants – can the parent reliably tell whether an infant is enjoying a particular food? Enjoyment in this instance was based on the parent's perception of their child's like or dislike of a food. It is a subjective measure that may be based on how much a child eats, whether they are enthusiastic about a food, or whether they throw it off the high chair tray or turn their face away from a spoon, for example. To my knowledge, this approach has not been previously undertaken when comparing specific foods preferred by weaning styles in this age group. However, a study from the BLISS group measured preference by looking at whether a food was actually consumed by an infant at 12 months (Morison et al., 2018) and another small study has compared preferences for types of foods (Townsend and Pitchford, 2012).

Perception of enjoyment could also be influenced by a parent's beliefs – if they are emotionally invested in BLW being a success or believe it's the "right" way to wean, they may be more likely to think their child is enjoying their food: if this was the case one would expect a very high proportion of the BLW groups to say their baby was enjoying most foods. Indeed, this has been the case in several qualitative studies investigating those using BLW with their children, where perceptions of parents about their infants experiences has been overwhelmingly positive (Arden and Abbott, 2014; Brown and Lee, 2013; Cameron et al., 2012a; D'Andrea et al., 2016).

Fussiness and enjoyment of food may also be influenced by food exposure. In studies with older children exposure through repeated offering has been found to be vital in increasing acceptance of new foods in childhood (Birch and Marlin, 1982; Cooke, 2007). As demonstrated by the adult participants in the previously mentioned study of pureed food acceptance (Keller and Duizer, 2014), purees are often similar in taste and texture, meaning infants may not be able to distinguish separate, specific food flavours, which may make acceptance harder as exposure is less concrete and enjoyment may be lower. One vegetable puree may be harder to distinguish from another, which may make the process of food acceptance through repeated exposure more drawn out, than being exposed to foods that look and taste quite different, such as a steamed carrot stick and a broccoli stalk for example.

In this study, babies introduced to solids using BLW were offered different types of foods when compared to those being spoon-fed and consumed them more often. For example, BLW babies were more likely to try high protein foods such as meat and fish, and tried a wider variety of food types compared to TW babies who were more likely to have tried infant cereals and convenience foods such as biscuits and rusks, and these types foods were eaten more often according to the FFQ. This is similar to findings in previous research (Fu et al., 2018). Interestingly, Fu et al (2018) found that BLW infants were less likely to consume "more fruits than vegetables" at the start of solid food introduction when compared with their TW group i.e. vegetables were offered more than fruits. It would seem that parents using BLW in the BLISS study offered a greater variety of foods, perhaps because of the practice of feeding "family foods", rather than relying on commercial purees or baby foods, of which there are a limited variety that BLW babies were exposed to a greater variety of tastes and textures from an early age (Morison et al., 2018).

Exposure to 'real' foods in their whole form as against purees may affect infant preferences and fussy eating, or rather, exposure to high levels of puree and shop bought baby foods may affect food preferences, increasing fussy eating. Composite meals and ready-made foods were more common in the traditionally weaned group and this could be problematic for eating behaviour longer term. According to a review of commercial baby foods in the UK, infant foods tend to be fairly sweet: even those made with vegetables tend to use sweeter varieties like carrot and sweet potato (Crawley, 2017), while BLW encourages offering all sorts of flavours and textures from whole foods, such as the slight bitterness of broccoli stalks, savoury strips of omelette or creamy avocado chunks. The similarity in texture and flavour of purees and pouches may mean that as parents try and introduce new flavours and textures as their babies grow, they are not accepted (Coulthard et al., 2009).

However, when looking at exposure and frequency of consumption of foods, not all findings were positive for those following a BLW approach. Those in the loose BLW group were more likely to have been exposed to chips, pizza and puddings than the other groups, although these results did not survive the correction for multiple tests. Yoghurt was also eaten less often by the strict BLW group, although both BLW groups had a more frequent consumption of cheese than the TW group. This is probably because of the form these foods take – cheese can be self-fed in chunks or in sandwiches and yoghurt is generally spoon-fed. BLW also had lower exposure to iron fortified cereals through all age groups and this finding withstood correction for multiple tests, which is a pattern seen in other studies examining intake (Fu et al., 2018; Morison et al., 2016).

There are several reasons why these differences might be occurring. First, the weaning approach may mean that certain foods are more likely to be introduced. For example, those in the strict BLW group were more likely to have tried meat, eggs and citrus fruits, plus this group ate these foods more frequently. These foods all lend themselves to self-feeding: meat can be cut into chunks and chewed/sucked by infants, even if they have no teeth, while egg can be made into an omelette that can be cut into soft strips to be eaten. Because BLW promotes eating family foods (Rapley and Murkett, 2008; Rowan and Harris, 2012), babies weaned using this method are offered more family foods, which are likely to include meat and eggs, and although meat can be cooked and pureed, eggs and citrus fruit are not commonly pureed foods, which is probably why they were eaten less frequently by TW infants.

Fruit can be an easy-to-grasp finger food: mandarin segments, bananas, chopped berries, melon slices, for example, so it might be more popular with parents using BLW. However, this was not the case for infants following a loose BLW approach, who had a higher consumption of tinned fruit, which was part of a pattern of increased use of processed or pre-packaged foods such as chips, pizza and puddings in the loose BLW weaning group, however these findings did not survive correction for multiple tests.

Although not significant when corrected, this was a consistent finding and it is possible that the use of processed/convenience foods by these parents is due to a misunderstanding about what constitutes foods suitable for baby-led weaning. Although finger foods are of course used for BLW, many of these are convenient-to-use, pre-packaged foods and parents still have to be aware of their salt, fat and sugar content. Just because a food can be self-fed, it doesn't mean that it's suitable for an infant. However, this pattern of feeding may simply be a reflection of infant and toddler diets in the wider community, given the results of the latest UK National Diet and Nutrition Survey and the 2018 Health Survey for England, which showed toddlers aged 1.5-3 years ate an average of 170g of fruit and vegetables daily (the equivalent of just two portions), while 13% of toddlers kept free sugar consumption at a maximum of 5% and all age groups exceeded saturated fat consumption (NHS, 2019a; PHE, 2019). As well as possibly misunderstanding what constitutes suitable weaning food, parents may use convenience foods because they seem a safe option with official-looking guidance printed on the packaging, indicating apparent age appropriateness: for example, they may have choking concerns but assume that pre-packaged foods are less likely to be a choking risk than say, a piece of fruit. Of course it may be that these foods are simply easy options for busy parents who need something quick and easy to feed their child when out and about or they may be interpreting the perceived 'benefits of self-feeding' as applying to convenience bought snacks too.

However, it should be noted that differences in exposure and variability of consumption for foods did reduce over time. It is likely that this is in part due to traditionally weaned infants being exposed to more finger and family foods as they move through the weaning process, naturally introducing them to more foods and reducing the gap. This is in line with findings from the BLISS trial where initial differences in intakes of different food groups at 7 months disappeared by 12 months of age (Daniels, Taylor, Williams, Gibson, Fleming, et al., 2018; Williams Erickson et al., 2018). However another paper from this group found that at 24 months the BLW infants did eat a wider variety of fruit and vegetables (Morison et al., 2018). Here our findings suggest that although TW infants 'catch up', using a BLW approach may encourage infants to try a larger variety of foods at a younger age.

When considering the reasons behind these differences in foods offered, it could also be that parents who are drawn to different approaches have different backgrounds that may affect their food choices. In other studies, mothers who adopt BLW are more likely to have a higher level of education or occupational role (Brown and Lee, 2011a, 2011c). We know that socio-economic factors influence dietary intake, with a higher SES linked to greater fruit and vegetable intake and lower red/processed meat consumption in the latest UK National Diet and Nutrition Survey (Maguire and Monsivais, 2015). Certainly the use of brown bread by the strict BLW group and white bread in the loose BLW group could indicate that parent background and beliefs about food are driving at least some of the choices made, as there is evidence for parental socio-economic status affecting the diets of their children (Fernández-Alvira et al., 2015; Maguire and Monsivais, 2015; Smithers et al., 2012). However although BLW mothers were older than those following a traditional approach, no significant difference occurred for education. Income was not measured; something future research may wish to consider in more depth, particularly given in study one, some health professionals worried about the cost of following a BLW approach.

Limitations

Although the results of this survey have added useful evidence for the eating patterns and behaviours of infants using Baby-Led Weaning in the UK, it is not without limitations. Firstly, there were limitations around recruitment, sampling and survey methodology as discussed in chapter three. The data was also generated by a self-reported Food Frequency Questionnaire, which has its limitations. For example, it cannot be used to measure intake accurately if food is not weighed and the frequency of consumption may not be correctly recalled (Bingham et al., 1994; Kristal, Peters, & Potter, 2005). Like other dietary assessment tools, FFQs can generate errors in measurement due to the nature of the food (is it recorded as a lasagne or are foods recorded as constituent parts), demographic characteristics (e.g. sex, age, ethnicity, education, and income) and the need to remember how often the food is consumed accurately. There are also concerns about whether they can accurately measure regular, daily intakes (Amoutzopoulos et al., 2020). Additionally, the food list was not exhaustive and may have produced biased or unbalanced results, if a regularly consumed food was not listed or recorded. In addition, parents may have wanted their infant's diet to appear more healthy or more representative of what a "good" baby-led weaning diet should consist of, which may have influenced them to change their reporting. However, FFQs are still widely used in epidemiological research when comparing the diets of large groups and costs must be considered. Critically, they have been validated for use in this age group (Marriott et al., 2009; Marriott et al., 2008).

Another limitation was the separate analysis of individual age groups rather than using a 3 x 3 weaning group x age group design, which compounded issues of multiple testing. Although this design was initially chosen because of the clear difference in what infants are able to eat at the start and end of the weaning process, secondary analysis using a multifactorial design could be carried out in future research.

Finally, the sample itself may have been biased due to the nature of those who chose to introduce solids using baby-led weaning, as previous research has shown mothers who use BLW tend to be older, more educated and from a higher socio-economic background. This could result in one sub-group of the sample having a different background than another, although this was accounted for when demographic factors were compared between weaning styles and there was little difference between groups.

Next steps

This study highlighted reported differences in infant eating behaviour and exposure to different types of foods. It highlighted that at least for parental perceptions of eating behaviour, infants following a BLW approach have lower levels of fussy eating and greater ability to self-regulate their appetite. They are also exposed to a wider variety of foods, particularly those high in protein, whilst having lower exposure to ready-made or snack-based foods.

This suggests that concerns raised in study one may be unfounded; BLW infants are being exposed to a wide variety of nutrients and are perceived to enjoy and accept a range of foods. However, although this data is useful and includes a larger sample size, it does not actually measure food intake, rather food exposure and perceptions of food acceptance and enjoyment. Offering an infant a food is not the same as them actually consuming that food. In study one health professionals raised the concept of waste or avoidance of food. Furthermore, although a useful tool for comparison, FFQ questionnaires as noted in the limitations do not measure amounts given or volumes given over 'more than once a day'.

Therefore, the next step of this thesis is to explore differences in diet using a more detailed measure: a 24 hour dietary recall for infants following different weaning approaches.

Chapter 6: Using a twenty-four-hour recall to explore differences in intake between weaning groups

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Introduction

This next chapter builds on the findings in studies one and two to explore whether differences occur in the nutrient intake of infants according to weaning approach. As noted at the end of the last study, there a number of limitations in using a Food Frequency Questionnaire to understand nutrient intake. Although they are quick and easy to use, and therefore are likely to be filled in by larger samples, they do not contain sufficient detail to examine nutrient intake in greater depth. At the time this study was carried out, there was no prior literature using a 24 hour recall to investigate intake in a baby-led weaning sample, although a similar recall study was published subsequently (Alpers et al., 2019).

The aim of this study was therefore to use a 24-hour recall to examine differences in foods offered to infants aged 6 – 12 months dependent on whether they were following a baby-led or traditional weaning approach. It was designed to contribute data to research questions:

R4. What are the differences in macro/micronutrient intake between groups?
R5. Is BLW sufficient or significantly different to traditional weaning?

Methodology

Design

The data in this study was provided by a subset of the participants who took part in the same survey used in study two. Not all participants of the survey reported in chapter 5 chose to fill in the 24 hour recall section. This was likely partly due to the increased time load of remembering and filling in the recall but also because participants were encouraged to leave it blank if they could not accurately recall what their infant had consumed the day before. As there were significantly fewer participants, alongside a depth of data provided in that one section of the questionnaire, the decision was made to present these findings in a separate chapter to contextualise these clearly within the sample who completed this part of the study. For a reminder of details of the study design and procedure please see chapter four and the schematic representation on page sixteen.

The section of the survey reported in this chapter used a 24 hour dietary recall design. During a 24 hour recall, respondents are asked to give as much detail as they can about each type of food and drink consumed, such as brands and portions sizes and the time of day they are consumed. Recalls are either taken by an interviewer, over the phone or in person, or are self-reported on paper or more recently over the internet, as was the case in this study (Castell, Serra-Majem, & Ribas-Barba, 2015).

Dietary assessments using 24 hour recalls are widely used in nutrition intake studies as they are cheap, relatively easy to administer and offer a "snapshot" of a participant's diet. Other benefits are that they allow grouping of types of food, such as sweetened beverages or green vegetables, and totals can then be aggregated and compared between groups. They are particularly useful for population or group studies, and have been validated for this purpose (Biro, Hulshof, Ovesen, Amorim Cruz, & Group, 2002; Karvetti and Knuts, 1985).

There are however, limitations with 24 hour recalls. They cannot be used for total nutrient intake because participants generally do not weigh food, they are simply recalling as accurately as possible what has been eaten or drunk, so a recall can't calculate nutrient content accurately, and there may be underreporting of total energy intake (Poslusna, Ruprich, de Vries, Jakubikova, & van't Veer, 2009; Prentice et al., 2011). Therefore another limitation is the reliance on memory, which means a recall may not be useful in certain age groups and may be subject to respondent bias – not wanting to report a food perceived as unhealthy, for example. In addition, if only one recall is carried out, this does not produce a picture of habitual food intake.

Participants and procedure

All participants in study two (chapter five) were invited to complete a 24 hour recall section in the wider survey. Participants were asked to complete it if they could recall the foods their infant had eaten in the previous day. If they could not remember, or were not responsible for overseeing their infant's diet the day before, they were asked not to continue with this part of the questionnaire. This meant that a significant proportion of participants did not complete this section and the limitations of this approach are considered in the discussion. In total, 180 parents (178 mothers and 2 fathers) completed this measure, 61% of the 297 parents who completed the full survey.

Measures

For further details of the survey please see the study outlined in chapter four. This section considers the inclusion of the 24 hour recall section in the survey. In this section participants were asked to give a recall of the foods and drinks, including milk feeds of breast or formula milk, offered to their baby over the previous 24 hours.
The question read:

"What did your child eat yesterday (or the last day your bay was in your care)? Please note everything that your child ate and drank, including quantities of formula and cow's milk. If breast feeding, please note how long your baby nursed for at each session".

Parents were given a brief example of what the recall might contain and completed the recall in an open-ended box with unlimited character space:

For example:
7am Follow-on formula 200ml
9am Whole wheat toast with butter 1 slice
11am Follow-on formula 200ml
1pm 1 jar chicken and veg baby food 50ml
3pm 8" banana, half
6pm Pureed carrots 50ml

Reliability and validity of 24 hour recalls

Like Food Frequency Questionnaires, 24 hour recalls are a cost-effective, easy to administer dietary assessment tool and can provide a higher degree of detail with regard to portion size and quantity. Like FFQs they are also used in comparison of large groups and in epidemiological studies including the USA National Health and Nutrition Examination Survey (NHANES) (CDC, 2020). As noted in the design section, 24 hour recalls have their limitations. However, in spite of these issues, 24 hour recalls have been validated with weighed food records (Bingham et al., 1994; Burrows, Martin, & Collins, 2010) and used in this age group (6-12 months) (Sharma et al., 2013). Interestingly, a recent validation study for a new automated online 24 hour recall, found it was comparable with an interviewer directed recall and was validated with biomarkers of certain nutrients (Wark et al., 2018).

In spite of the wide use of 24 hour recalls in large scale intake studies, it should be noted that one review study found weighed food records the most accurate when compared to the doubly-labelled water method (a measurable biomarker) in recording energy intake in younger children aged 6 months to 4 years of age (Burrows et al., 2010).

Data Analysis

As described in study two, participants were divided into three different weaning groups, to reflect the way that baby-led weaning is practiced. Participants remained in the same group as per study two. Likewise, participants remained in the same age group for analyses i.e. 6 – 8 months, 9 – 10 months and 11 – 12 months.

Recall entries were downloaded and examined. Responses were excluded if they were only partially completed e.g. where it was clear that the recall had been started but not completed (e.g. "8am breast fed for 10 minutes, 9am 3 spoons of baby rice" as the only items noted).

Next, the data was examined in relation to food group exposures, as against accurate nutrient intake. As is typical in 24 hour recall studies, most responses had not given detailed weighed amounts of food but had instead given a description of the foods offered (e.g. "two spoons of macaroni cheese" rather than 50g macaroni cheese), it was decided that intake should be assessed using a count of food type exposures i.e. how often the infant had eaten a certain type of food, rather than an analysis of individual nutrient levels. This method of assessing intake had previously been used in a UK study focused on BLW and infant preferences (Townsend and Pitchford, 2012).

Milk feeds were classified as breast, formula, mixed (where both types of feeding had occurred in the same day) or none, which either meant the respondent had omitted reporting their milk feeds or the child had progressed to drinking cow's milk. This was only seen in the eldest 11-12 month age group.

All foods reported by parents were classified into one of the following groups as shown in table twenty six, which were adapted from those used in a previous British study comparing food preferences between infants using BLW and traditional spoon feeding (which was itself based on a previous British on children's food preferences) and the iron-rich food group used in the New Zealand BLISS studies (Cameron et al., 2015; Townsend and Pitchford, 2012; Wardle, Sanderson, Leigh Gibson, & Rapoport, 2001)

Table 30: 24 hour recall food group classifications

Group	**Examples**
Milk feeds	Breast, formula, cow's milk, alternatives
Carbohydrates	Cereals, pasta, rice, potatoes or bread
Vegetables	All vegetables, including starchy varieties
Fruit	All fruits, whether tinned, fresh or frozen
Savoury snacks	Processed snacks such as baby crisps, breadsticks or crackers
Sweet foods	Desserts, chocolate, and puddings
Protein	Meat, fish poultry, eggs, tofu, pulses and legumes
Dairy	Milk, cheese and yoghurts from cow's or goat's milk
'Infant meals'	Composite meals where the individual components were pureed or where the individual components could not be discerned, such as commercial pureed baby food or a simple description such as "curry".
Iron containing foods	Beef, Chicken, Fish, Ham, Lamb, Bacon, Liver (including pâté), Luncheon sausage or other sausage, Pork, Salami, Processed meat

	sausages, Iron-fortified infant cereal, Baked beans, Lentils, Hummus, Chickpeas (other than hummus)

The iron-containing foods list, while not exhaustive, contains foods known to contain iron which may be offered to babies eating family foods, as may occur in baby-led weaning, or foods which may be incorporated into pureed meals or spoon-fed, such as infant cereals. This particular list was first used in the BLISS (Baby-Led Introduction to SolidS) study in New Zealand (Cameron et al., 2015). It should be noted that these foods are not foods necessarily recommended for babies, for example, bacon is too high in sodium to be suitable for infants, however, it was acknowledged by the BLISS study team that these foods while not being recommended, may still be offered, and both BLISS and this study aimed to document food choices rather than educate on healthy eating practices.

However, these foods were primarily included because of their iron content, the presence of haem iron (which has a more favourable absorption rate compared to non-haem iron from vegetarian sources), "meat, fish and poultry" (MFP) factor, the presence of which enhances iron absorption from all sources (Heath and Fairweather-Tait, 2002; Monsen et al., 1978), iron-fortified baby cereal and certain iron-containing legumes which would be commonly eaten by vegetarian infants in developed countries.

The foods in the iron-containing group were also counted in their primary food groups. In the case of roast chicken, for example, it would be counted in "protein" and "iron-rich food", while pureed spaghetti bolognaise would be counted as "meals" and "iron-rich food" and in the case of infant cereal, there would be a count for "carbohydrate" and one for "iron-rich food".

Analysis was performed by reading each 24-hour recall and counting the number of times each type of food was offered to the infant. Different vegetables were counted as separate offerings, for example a meal consisting of potatoes, fish, cheese sauce peas and carrots would have been noted as having 1 carbohydrate, 1 protein, 1 dairy, 2 vegetables and 1 iron-containing food.

Each response was scored and analysed using SPSS v.22 (IBM). Differences between the weaning groups in their consumption patterns were analysed using MANOVA. Post-hoc Bonferroni tests were carried out to clarify any significant differences between the groups.

Data was analysed for the full sample and then separately for the three infant age groups: 6 – 8 months, 9 -10 months, 11 – 12 months.

Results

One hundred and eighty parents (178 mothers and 2 fathers) completed this measure, as a subsample of 61% of the 297 parents who responded to the larger feeding survey described in chapter five. Parents' ages ranged from 18 to 44, with a mean age of 32 (SD 5.02). Further details of the participant demographic breakdown can be found in table thirty one, with the current sample in this study compared to the full sample.

Table 31: Demographic characteristics of 24-hour recall participants

		Current sample		**Full sample**	
Demographic	Group	N	%	N	%
Age	≤19	5	2.8	5	1.7
	20 – 24	7	3.9	20	6.7
	25 - 29	42	23.3	73	24.6
	30 - 34	71	39.4	108	36.4
	≥35	55	30.6	91	30.6
Education	No formal education	2	1.1	3	1.0
	GCSE	3	1.7	8	2.7
	A Level	26	14.4	48	16.1
	Degree or equivalent	87	48.3	138	46.5
	Postgraduate qualification	61	33.9	98	33.0
Marital status	Married	136	75.6	225	75.7
	Widowed	1	0.6	2	0.7
	Divorced	2	1.1	2	0.7
	Separated	3	1.7	4	1.3
	Domestic partnership/civil union	31	17.2	51	17.2
	Single	6	3.3	11	3.7
Employment	Full time	31	17.2	46	15.5
	Part time	27	15.0	47	15.8
	Parental leave	90	50.0	141	47.5
	Not working	32	17.8	63	21.2
Ethnicity	White (British, Irish)	159	88.2	254	85.5
	White other	9	5	17	5.7

	Gypsy/Irish Traveller	1	0.6	1	0.3
	Mixed ethnicity	5	2.8	10	3.4
	Asian	3	1.7	8	2.7
	Black/African/Caribbean/Black British	0	0	1	0.3
	Prefer not to disclose	3	1.7	6	2.0

Turning to the infants, 83 (46%) were female and 97 (54%) were male. Their mean age was 38.1 weeks (SD +/- 8.20). Eighty-three babies were in age group one (6 – 8 months), forty-five in group two (9 – 10 months) and fifty-two were in group three (11 – 12 months). Overall fifty-six were using strict baby-led weaning (minimal parental feeding), eighty-eight were using a looser form of BLW (self-feeding and some spoon feeding) and thirty-six were using traditional spoon-feeding. Table thirty two below shows the number of babies following each of the three weaning approaches across each of the three age groups.

Table 32: Respondents by weaning group and age group

		Weaning group					
		Strict		*Loose*		*Traditional*	
Age group	N	N	%	N	%	N	%
Group 1 **6 – 8 months**	83	19	22.9	45	54.2	19	22.9
Group 2 **9 – 10 months**	45	15	33.3	22	48.9	8	17.8
Group 3 **11- 12 months**	52	22	42.3	21	40.4	9	17.3
Overall	180	56	31.1	88	48.9	36	20.0

<u>Group One: Six to eight months</u>

Participants were also asked if they were currently breast, formula or mixed feeding for milk feeds. Given associations between milk feeding and later eating behaviour, the association between weaning group and milk feeding was examined using Chi Square, where a significant difference was found (X^2 (4, 83) = 14.992, p = .005). Table thirty three below shows that mothers who followed a strict baby-led style were more likely to be breastfeeding. Milk feeding type was therefore controlled for throughout further analyses.

Table 33: Age group 1 (6-8m) milk feeding style by self-identified weaning group

	Milk feeding style						
Weaning group	*Breast feeding*		*Formula feeding*		*Mixed*		**Total**
	N	%	N	%	N	%	N
Strict BLW	16	84.2	2	10.5	1	5.2	19
Loose BLW	29	64.4	12	26.7	4	8.9	45
Traditional	5	26.3	12	63.1	2	10.5	19
Total	50	60.2	26	31.3	7	8.4	83

Differences in food groups consumed were therefore then examined across the three weaning groups, using a MANCOVA, controlling for milk feeding type. No significant difference was found in infant age across the three weaning groups. Mean differences in intake between the three groups are shown below in table thirty four.

Table 34: Age group 1 - Intake by weaning group showing mean intake (SD)

Food group	**Strict BLW**	**Loose BLW**	**Traditional**	**Significance**
Milk Feeds	6.05 (1.75)	5.62 (1.97)	4.68 (2.24)	F (2, 75) = 2.413, p = .096
Carbohydrates	1.47 (.96)	1.65 (1.10)	1.11 (.81)	F (2, 75) = 1.895, p = .157
Vegetables	2.58 (1.64)	1.78 (1.64)	.58 (.90)	F (2, 75) = 8.637, p = .000
Fruit	1.68 (1.29)	1.50 (1.13)	1.68 (.75)	F (2, 75) = .275, p = .760
Savoury snacks	.05 (.23)	.22 (.42)	.16 (.50)	F (2, 75) = 1.159, p = .319
Sweet foods	.26 (.56)	.30 (.72)	.47 (.70)	F (2, 75) = .552, p = .578
Protein	.89 (.81)	.85 (.83)	.05 (.23)	F (2, 75) = 8.939, p = .000
Dairy	.53 (.61)	.75 (.78)	.74 (.93)	F (2, 75) = .567, p = .570
Meals	.32 (.58)	.32 (.47)	1.05 (.91)	F (2, 75) = 9.646, p = .000
Iron-rich foods	.74 (.73)	.67 (.66)	.47 (.77)	F (2, 75) = .759, p = .472

Table shading denotes significance at p < 0.05

The results showed significant differences in consumption for vegetables, protein and "meals" (foods which contained a mixture of different food groups such as lasagne or pureed meals). Notably, there was no significant difference in the consumption of iron-containing foods, with the strict BLW group having the highest consumption.

Post hoc Bonferroni tests were used to explore differences between weaning groups finding:

- In terms of vegetable portions, there were significant differences between the strict BLW and traditional groups p = .000, and loose BLW and traditional groups p = .016, but intake between the two BLW groups was not significantly different (p = .466).

- For protein foods such as meat, fish and beans: the strict and loose BLW ate most, while the traditional group least. Post hoc Bonferroni tests found significant differences were found between the strict BLW and traditional groups (p = .002), and loose BLW and traditional groups (p < .001). There was no significant difference in consumption between the two BLW groups (p = 1.000).

- For meals, the strict and loose BLW groups ate less than the traditional group, and post hoc tests found significant differences between the strict BLW and traditional groups (p = .002) and loose and BLW and traditional groups (p = .000). There was no significant difference between the two BLW groups (p = 1.000).

<u>Group 2 (9-10 months)</u>

In the second age group (9-10 months), 15 were following a strict BLW approach, 22 were using loose BLW and 8 were using traditional weaning, see table thirty one. In terms of milk feeding, 26 were breast-feeding, 14 were formula feeding and 4 were using a mixed feeding approach. One person in the loose BLW group did not respond with their feeding style, which is reflected in the table thirty five below.

Table 35: Age group 2 (9-10 months) by weaning group and milk feeding style

	Milk feeding style						
Weaning group	*Breast feeding*		*Formula feeding*		*Mixed*		**Total**
	N	%	N	%	N	%	
Strict BLW	13	86.7	1	6.7	1	6.7	15
Loose BLW	12	54.5	8	36.3	1	4.5	21
Traditional	1	12.5	5	62.5	2	25.0	8
Total	26	59.1	14	31.8	4	9.1	44

When a Chi square test was carried out, there was a significant correlation between weaning group and milk feeding style in this age group (X^2 (6, 44) = 14.586, p = .024), with 86.7% of the strict BLW group breastfeeding but only 54.5% of the loose BLW group and just 12.5% of the traditional group. In the traditional group, 62.5% of participants used formula feeding.

A MANCOVA was carried out to compare average intake by weaning group, while controlling for the style of milk feeding style. The results are shown in table thirty six, below. Significant differences in intake means were seen in the number of milk feeds and dairy consumption, with milk feeds being highest in the strict BLW group, with an average of 5.60 per 24 hours. For dairy, consumption was lowest in the strict BLW group with .80 servings, but 1.68 and 1.71 servings in the loose BLW and traditional groups respectively.

Table 36: Age group 2 - Intake by weaning group showing mean intake (SD)

Food group	**Strict BLW**	**Loose BLW**	**Traditional**	**Significance**
Milk Feeds	5.60 (2.53)	3.55 (1.50)	3.71 (.76)	F (2, 41) = 5.873, p = .006
Carbohydrates	2.00 (1.20)	2.50 (.96)	2.14 (1.07)	F (2, 41) = 1.084, p = .360
Vegetables	2.00 (1.73)	1.59 (1.40)	2.43 (2.30)	F (2, 41) = .739, p = .484
Fruit	2.13 (1.41)	2.05 (1.29)	2.43 (1.13)	F (2, 41) = .227, p = .798
Savoury snacks	.67 (1.23)	.68 (.72)	.71 (.76)	F (2, 41) = .006, p = .994

Sweet foods	.27 (.46)	.50 (.60)	.43 (.54)	F (2, 41) = .825, p = .445
Protein	1.53 (.99)	1.23 (1.48)	1.57 (.54)	F (2, 41) = .375, p = .690
Dairy	.80 (.68)	1.68 (1.17)	1.71 (1.50)	F (2, 41) = 3.303, p = .047
Meals	.33 (.49)	.64 (.66)	.86 (1.07)	F (2, 41) = 1.610, p = .212
Fe foods	1.13 (.64)	1.14 (.71)	1.86 (.90)	F (2, 41) = 2.970, p = .062

Table shading denotes significance at $p < 0.05$

The results showed significant differences in number of milk feeds and dairy consumption. Again notably, there was no difference in consumption of iron rich foods. Post hoc Bonferroni tests were used to explore differences between weaning groups finding:

- For the number of milk feeds, there was a significant difference between the strict and loose BLW groups (p = .006), but not the strict BLW and traditional weaning groups (p = .095) or the loose BLW and traditional groups (p = 1.000).

- For dairy consumption, the strict BLW group consumed the fewest portions, compared to the loose BLW and traditional groups. However the difference between groups did not survive a post-hoc Bonferroni test. The difference between the two BLW groups reachied a significance of p = .060, while the difference between the TW and strict BLW groups was p = .222 and that of the TW and loose BLW groups was p = 1.000.

Group 3 (11 – 12 months)

In the third age group (11-12 months), 22 were following a strict BLW approach, 21 were using loose BLW and 9 were using traditional weaning, see table thirty seven. In terms of milk feeding, 26 were breast-feeding, 14 were formula feeding and 4 were using a mixed feeding approach.

Table 37: Age group 3 (11-12 months) by weaning group and milk feeding style

	Milk feeding style										
Weaning group	*Breast*		*Formula*		*Mixed*		*EBM*		*None*		**Total**
	N	%	N	%	N	%	N	%	N	%	
Strict BLW	14	63.6	4	18.2	1	4.5	1	4.5	2	9	22
Loose BLW	14	66.7	4	19.0	0	0.0	0	0.0	3	14.3	21
Traditional	5	55.6	2	22.2	1	11.1	0	0.0	1	11.1	9
Total	33	63.5	10	19.2	2	3.9	1	1.9	6	11.5	52

In this age group, there was no significant link between weaning group and method of milk feeding when a Chi square test was carried out (X^2 (8, 52) = 3.865, p = .941), although in the strict BLW group, 63.6% of participants were breastfeeding and just 18.2% used formula. A similar pattern was seen in the loose BLW group. In this age group several respondents used expressed breast milk (EBM) or did not report giving their babies any milk, or reported using cow's milk, and these were classed as using "none". A MANCOVA was carried out to compare average intake by weaning group, while controlling for the style of milk feeding. The results are shown in table thirty eight.

Table 38: Age group 3 – Intake by weaning group showing mean intake (SD)

Food group	**Strict BLW**	**Loose BLW**	**Traditional**	**Significance**
Milk Feeds	4.00 (2.25)	3.53 (2.09)	2.89 (2.09)	F (2, 47) = .873, p = .425
Carbohydrates	2.55 (1.01)	2.42 (.90)	2.11 (.78)	F (2, 47) = .691, p = .506
Vegetables	1.77 (1.41)	1.79 (1.13)	1.11 (1.27)	F (2, 47) = .998, p = .376
Fruit	2.18 (1.53)	2.89 (1.60)	2.11 (.93)	F (2, 47) = 1.469, p = .241
Savoury snacks	.32 (.72)	1.05 (.91)	.67 (.71)	F (2, 47) = 4.349, p = .018
Sweet foods	.45 (.60)	.53 (.61)	.11 (.33)	F (2, 47) = 1.714, p = .191
Protein	1.55 (.91)	1.16 (.83)	.78 (.67)	F (2, 47) = 2.861, p = .067
Dairy	1.14 (1.13)	2.47 (1.43)	2.22 (1.72)	F (2, 47) = 5.365, p = .008
Meals	.27 (.55)	.58 (.69)	.89 (.60)	F (2, 47) = 3.437, p = .040

Fe foods	1.45 (.67)	1.11 (.74)	1.33 (.50)	F (2, 47) = 1.389, p = .259

Table shading denotes significance at p < 0.05

Two members of the loose BLW group did not report the number of milk feeds and so were not included in these results. Intake of savoury snacks, dairy products and composite meals differed significantly between the three weaning groups. Again no difference was seen for iron rich foods. Post hoc Bonferroni tests were used to explore differences between weaning groups finding:

- For savoury snacks, there was a significant difference between the strict and loose BLW groups (p = .015), but no significant difference between the strict BLW and TW groups (p = .821) or between the loose BLW and TW groups (p = .709).
- For dairy, consumption there was a significant difference between the strict and loose BLW groups (p = .009), but not between the strict BLW and TW groups (p = .148) or between the loose BLW and TW groups (p = 1.000).
- For composite meal consumption there was a significant difference between the strict BLW and traditional weaning groups (p = .045), but not between the two BLW groups (p = .359), or between the loose BLW and TW groups (p = .662).

Discussion

This study was a 24-hour recall examining the differences in food intake between infants weaned using strict baby-led weaning, a looser version of BLW or a traditional spoon-feeding approach. Participants were asked to list all the food and drinks, including milk feeds, which their infants had consumed. The recalls were examined and each portion of different types of food was counted along with numbers of milk feeds. The mean of the portions of each food type offered was compared between the three weaning groups and three different age groups.

Overall, the findings showed several significant differences between exposures to foods of the different weaning groups and age groups, which are outlined below. For some foods, traditional group had more exposures, for others the strict BLW group had the most. For intake of iron-containing foods, there were no significant differences in any of the age groups.

Age group 1: 6-8 months

In the youngest age group of babies, there were several significant differences in intake. Vegetables were offered most often in the strict baby-led weaning group and least in the traditional group, which may be a benefit of BLW, as early and frequent exposure to the bitter tastes in vegetables may increase greater acceptance of these tastes when babies are older (Barends, de Vries, Mojet, & de Graaf, 2013; Coulthard, Harris, & Emmett, 2010; Hetherington et al., 2015; Lange et al., 2013). Higher consumption of vegetables in the strict BLW group at this age may be expected because first weaning foods for babies weaned in this way are often chunks or pieces of vegetables, like well-cooked broccoli stalks, which the baby can grasp and self-feed. Alternatively, it could be the case that parents following BLW are offering more vegetables than those using a traditional approach. Given that demographic factors such as maternal education and age were controlled for, more investigation would be needed to clarify this, although the FFQ and exposure data outline in chapter three did suggest that infants BLW infants had a higher consumption of some vegetables.

Protein consumption (which included meat, poultry, fish, legumes, soya products such as tofu, and eggs but excluded dairy products) was also significantly different between the groups, with the strict and loose BLW groups having a similar consumption of just under one portion a day and the traditional group consuming just .05 a day. Again, this is probably due to the different types of foods offered in the different weaning methods. BLW babies may be offered a strip of omelette, piece of meat or hummus on toast as part of a meal, whereas spoon-fed babies may not be given high protein foods until later in the weaning process.

Indeed no significant difference in protein consumption between groups was observed in either age group of older babies, suggesting that protein foods were not offered more frequently to traditionally weaned babies until later in the weaning process. This would not be unusual given that many "first foods" given to traditionally weaned babies are comprised of fruit and vegetable purees. This finding may challenge the assumption that baby-led weaned babies are not receiving nutrient-dense foods when solids are first introduced, however, babies can get most if not all of their protein requirements from milk at this stage, with infants having protein needs of 5-6% of kilocalories per day or 13.7g for babies of 7-9 months (WHO, 2003).

Another difference to be expected was the traditional group having the highest consumption of "composite meals". The meals group was used to account for meals composed of multiple ingredients including purees, where it was unclear what the individual components of a dish were to the researcher or where the parent had written, for example, "baby food jar, pasta meal". Higher consumption of composite meals would be expected in the traditionally weaned group at this age because pureed family meals or baby food jars are often used in traditional spoon-feeding (Brown and Lee, 2011a). In fact, composite meal consumption was highest in the traditional weaning groups for all ages.

This may have implications for energy and sugar intake because according to a recent report by First Steps Nutrition, commercial jarred baby food may provide portion sizes that provide more calories from solid foods than a child of this age requires (Crawley, 2017). For babies aged 7-9 months, the researchers found that 61% of products aimed at this age group contained more energy than necessary yet at the same time, many infant foods were not as energy dense as they should be, providing little energy but lots of bulk.

Commercial baby foods may also contain excess sugar: one UK study found that sweet, spoonable foods contained twice as many sugars as breast milk and dry, non-fruit snacks, such as rusks, contained four times as much sugar (Garcia et al., 2013). Cleary this is an issue with regards to dental health as well as potentially excess energy consumption, but additionally regular intake of sweeter foods may impact on a child's acceptance of less palatable but more nutrient dense foods such as vegetables (Barends et al., 2013). The slightly sweet, bland similarity of many pureed weaning foods may also make introducing other foods harder, as there is some evidence that introducing a variety of flavours increases the acceptance of novel flavours in infants (Gerrish and Mennella, 2001).

Age group 2: 9-10 months

In this age group, significant differences between weaning groups were only seen between the number of milk feeds and dairy product consumption. The highest number of milk feeds was seen in the strict BLW group. This was probably due to the majority in this group (86.7%) breastfeeding, which tends to lead to more frequent feeds per day than formula feeding. Formula packs indicate that babies should have 5-6 feeds per 24 hours in their first few months, which would mean feeds every 3-4 hours, but 6-18 (or more) breastfeeds per 24 hours, of smaller volumes, would be considered normal (Kent et al., 2006), due in part to the easier digestibility of breast milk when compared to formula. In this age group, milk feeds ranged from a mean (SD) of 3.55 (1.50) in the loose BLW group to 5.60 (2.53) in the strict BLW group.

For dairy produce, the loose BLW and traditional groups consumed over twice as much as the strict BLW group, however, the significant difference did not survive a Bonferroni test. It is still worth noting this difference in consumption, which could have been because popular dairy products for infants being introduced to solids include yoghurt and fromage frais, which are usually eaten with a spoon.

At this age, many babies would not be able to hold a spoon and put it into their mouth without creating undue mess, therefore infants weaned using BLW may not be eating as many dairy products as those being spoon-fed. In fact, when the original data were re-examined, the main sources of dairy products for the infants in the strict BLW group at this age were cream cheese or soft cheese on toast or in sandwiches, whereas for those in the traditional group, fromage frais and yogurt were more common offerings. Given the sugar content of yoghurts aimed at young children, this may be a good thing, and breast milk or formula should be supplying most calcium needs at this age (Jenness, 1979; Martin, Ling, & Blackburn, 2016).

Age group 3: 11-12 months

The pattern of the strict BLW group having the lowest dairy consumption was also seen in this age group, with the loose and TW groups consuming over twice as many portions of dairy foods. This was probably due to BLW infants not being spoon-fed yoghurt and fromage as previously mentioned, although at this age it is acceptable for babies to consume cow's milk, so this suggests that these babies were not drinking cow's milk, possibly because of continued breast feeding.

In this last group of infants, significant differences in intake were also seen in savoury snacks and composite meals. Composite meals were, again, most frequently consumed in the traditional weaning group, at a stage when children should be moving towards a family diet. The NHS Start4Life website (https://www.nhs.uk/start4life) suggests that by the time a baby is 12 months old they should be eating family foods, albeit in smaller portions (PHE, 2020).

The finding that savoury snack items such as breadsticks, crackers and crisps, were eaten most often in the loose BLW group, could indicate a reliance on processed snack foods in this weaning group and could demonstrate one potential disadvantage of baby-led weaning, a possible over-use of processed, carbohydrate rich finger foods. Many of these snack are designed for infants and marketed to their parents as a convenient food to be used on the go, but they can also be high in sodium and sugar, particularly if targeted at adults.

A preference for carbohydrates amongst babies weaned using BLW was indeed observed in one British study (Townsend and Pitchford, 2012). However in this study, there was no significant difference in carbohydrate exposure between the weaning groups and the strict BLW group were eating the fewest savoury snack foods, suggesting that these parents were perhaps more health conscious than those following a looser approach. It is possible that those following a looser form of BLW may be less confident in the method and more comfortable offering ready-made finger foods. The number of commercially available finger foods has grown rapidly in the last ten years, providing a ready supply of these snack for busy parents (Technavio, 2017).

With regard to consumption of composite meals in this study, there has been some concern over the nutrient-density and amount of energy supplied by commercially prepared infant foods of the kind widely used by parents in this study (Crawley, 2017; Garcia et al., 2013; Loughrill, Govinden, & Zand, 2016; Loughrill, Wray, Christides, & Zand, 2016; Loughrill and Zand, 2016).

In a review of popular commercially available infant foods, the First Steps Nutrition Trust found that the nutrient density of commercial foods was likely to be lower than homemade foods due to the inclusion of water, but reported that the manufacturers' recommended portion sizes are high and kcal content per portion may actually be higher than that required in infancy (Crawley, 2017). Indeed, one study on the micronutrient content of infant foods found that although fortified snack foods and commercial infant foods could be an important source of micronutrients in babies' diets, overuse of these foods could also contribute to excess energy intake and an imbalance of micronutrients due to possible competition for absorption in the gut (Loughrill, Wray, et al., 2016). Therefore more research is needed to ascertain nutrient intakes of infants weaned using commercial and home-prepared foods.

In addition to the different intake rates between weaning groups, there were also several other points of interest, most notably that intake of iron-containing foods showed no significant difference between weaning groups in any age category.
This is noteworthy, as iron-deficiency in babies introduced to solids using BLW, has been cited as a potential issue by health professionals in several countries (Cameron et al., 2012a; D'Andrea et al., 2016). Therefore, one of the aims of this study was to examine the intake of iron-containing foods for infants weaned using BLW, as baby cereals would presumably not form a significant part of their early weaning diet. Infants weaned traditionally are often given spoonable, iron-fortified baby cereals, which may be why health professionals have expressed concerns about potentially low iron intake of babies weaned using BLW, as spoon feeding of cereals is less common using this method.

Iron deficiency in infancy can be an issue due to the increased need for iron during this period of rapid growth and iron deficiency anaemia in infancy may lead to developmental delays and behavioural problems (Beard, 2008; Lozoff et al., 2006; McLean, Cogswell, Egli, Wojdyla, & de Benoist, 2009). In Europe, the prevalence of iron-deficiency anaemia (IDA) in infants is estimated to be 2-3% at 6 – 9 months and 3-9% at 1 – 3 years of age (Domellof et al., 2014). Thus, adequate iron intake is important during the second half of the first year of life, when iron stored during gestation and transferred via the umbilical cord starts to decline. The increasing need for iron in the latter half of the first year of life is reflected in the UK Reference Nutrient Intake figures: at 4-6 months, 4.3mg iron is required, but this rises to 7.8mg per day between 7-12 months.

In the 11-12 month group, exposures to iron containing foods ranged from 1.11 in the loose BLW group to 1.45 in the strict BLW group. So although the findings of this study suggests that iron intake may in fact be similar across weaning methods, it is unknown whether this intake, along with either breast of formula milk, meets the UK RNI of 7.8mg per day for babies 7-12 months, and further study such as a weighed food record is required to assess nutrient intake more fully.

Although these results suggest that the method of weaning doesn't appear to significantly affect exposure to iron-containing foods, babies weaned using BLW were exposed to more nutrient dense foods such as protein and vegetables in age groups 1 and 3 and fewer commercially prepared meals in all age groups: as previously discussed, commercial infant foods often have higher sugar levels and lower nutrient density. Thus on balance, BLW babies may be consuming a more nutrient dense diet, but further research is needed.

The different ways that foods are presented i.e. as purees or whole foods may have an impact on later food choices for children. If the foods eaten by an infant are indistinguishable purees, it will delay the moment when the child realises what a food actually is, what it looks like and what it really tastes like: for example a brown puree of spaghetti bolognaise has many individual components – but may look, feel and possibly taste, indistinguishable from a puree of shepherd's pie. It doesn't teach the child about her own likes and dislikes nor about the characteristics of individual foods and gives no opportunity to explore food autonomously.

This lack of familiarity with food and its origins in later childhood can be seen in a survey of 5000 children aged 5-16 years by the British Nutrition Foundation (BNF) as part of their Healthy Eating Week. The BNF found that among 5-7 year olds, 18 % thought fish fingers were made of chicken, 14% said bacon is the produce of cows, sheep or chickens, and 23% said that bananas, roast chicken, broccoli and wholegrain bread belong in the dairy and alternatives food group (BNF, 2017).

This demonstrates a disconnect between these children and their food, which may well start in infancy, since babies who are offered foods in their whole form, such as a stick of carrot, pasta shells, a chunk of boiled potato or some strips of chicken, may be able to identify flavours and satiety of individual foods. This may have important implications for appetite and self-regulation later in childhood.

There are limitations to this study, as previously mentioned in chapter four, such as the self-selecting nature of the respondents, who were motivated to take part in the study.

Another is that the respondents in this sample may not have been representative of the UK population as they demonstrated much higher rates of breastfeeding than seen in the general population, independent of their weaning method. In the youngest 6-8 month age group for example, 60.2% were breastfeeding, 31.3% were formula feeding and 8.4% were mixed feeding. This is in contrast to the UK breastfeeding rates of about 1% of mothers exclusively breast feeding at 6 months (UNICEF, 2012). This pattern was also seen in the 9-10 month group, where 57.8% were breastfeeding, and the 11-12 month group where 63.5% were still breastfeeding. However it should be noted that milk-feeding style was controlled for when analysing the 24 hour recall results. In contrast, in the BLISS study group, at 7 months 51% were exclusively breastfeeding, 24% were using formula and 25% were mixed feeding. At 12 months, 43% were still exclusively breastfeeding, 33% used formula, 11% used mixed methods and 13% were not using breast of formula milk (Daniels, Taylor, Williams, Gibson, Fleming, et al., 2018). Thus although breastfeeding rates in both BLISS weaning group were also higher than population levels, they were not as high as those seen here.

There are also limitations with the methodology of 24 hour recalls. They do not provide detailed nutrient intake as participants generally don't weigh foods, and they are simply a snapshot of intake over the previous 24 hours. As such, there is also the potential for under or overreporting due to forgetfulness and bias (Poslusna et al., 2009; Prentice et al., 2011).

As previously noted in chapter five a further limitation of this study design, was the analysis of individual age groups rather than using a 3 x 3, weaning group x age group design. Again, although this design was chosen because of the difference in what infants eat at the start and end of the weaning process, as shown by the results of study two in chapter five, a secondary analysis using a multifactorial design could be carried out in future research.

In spite of the limitations of this work, it is interesting to note that there were significant differences found between the consumption of different types of food by infants being introduced to solid foods using baby-led weaning and those being spoon-fed. However, there was no difference in intake of iron-rich foods between weaning groups across all age groups, which has been cited as a possible issue in baby-led weaning for health professionals.

However, nutrient and energy intake was not specifically measured in this study due to a lack of sufficient detail provided by participants in the 24-hour recall design. Although this study provides useful information on food groups offered, and such a short recall allows a greater sample size, the next stage of the research needs to explore nutrient intake at a much more accurate level. Therefore, the decision was made to conduct one final study to explore specific nutrient and energy intake of infants following different weaning approaches using a 3-day weighed food diary.

Chapter 7: A three day weighed food record comparing intakes of infants aged 6-12 months using baby-led or traditional weaning

A version of this chapter entitled "Energy and nutrient intake for infants following baby-led and traditional weaning approaches" has been submitted to the Journal of Human Nutrition and Dietetics (Manuscript ID JHND-21-09-0499-OA) and is under second stage review at the time of submission.

Introduction

The study outlined in chapters six compared the intake of food groups offered to infants using baby-led and traditional weaning. This gave a broad picture of what the two groups were being offered in a 24 hour period. Overall, the results from the 24-hour recall study showed that infants following a baby-led approach were eating similar portions of key foods such as those rich in iron compared to those who were being spoon-fed, but had higher intakes of protein and vegetables and lower intakes of dairy products.

One strength of the previous study was that it could examine differences in food group exposure between those following baby-led or spoon-fed approaches in a large sample. However, although 24 hour recall measures are relatively quick and convenient for participants, they do not allow detailed measures of energy intake and nutrients (Bingham et al., 1994; Prentice et al., 2011). They also do not give an accurate distinction between food offered versus food consumed, thus a more comprehensive examination of diets was required to ascertain whether BLW was indeed safe and sufficient as a means of introducing solid foods.

Therefore, the final stage of this thesis was to conduct a detailed analysis of intake between weaning approaches using a three-day weighed diet diary. As will be presented in more detail later, this approach allows high level detail to be collected but requires much more participant time and motivation, hence sample sizes are typically smaller (Bingham et al., 1994; Gibson, 2005; Prentice et al., 2011)

In terms of where this sits within previous research using this approach, as noted in sections 2.7.4 and 2.7.5 of the literature review in chapter two, little research has examined the nutrient intake of infants following a baby-led or spoon-fed approach, with no weighed intake studies published from a UK perspective. Although one small UK study used a Food Frequency Questionnaire (Townsend and Pitchford, 2012) and another used both a FFQ and 24 hour recall (Alpers et al., 2019), none have used more detailed diet diary methods.

Again, the most detailed research comes from the BLISS study in New Zealand (Daniels et al., 2015). As part of their randomized controlled trial of infants following a baby-led or standard weaning approach, the team examined nutrient intake using three day diet records and blood samples at several points in children's lives. As described in the earlier review of current literature, neither iron nor zinc intake at 7 and 12 months were significantly different between weaning groups, nor were plasma ferritin or zinc at 12 months (Daniels, Taylor, Williams, Gibson, Fleming, et al., 2018; Daniels, Taylor, Williams, Gibson, Samman, et al., 2018). There were few differences between groups with the BLISS group consuming less saturated fat at 12 months but no differences at 24 months, both groups ate excess sodium and added sugar at this age (Williams Erickson et al., 2018).

Nutrient intake was also measured in another study by the same team, bringing together BLISS results and data from two small cross-sectional studies, reporting that those using BLW consumed more sodium, total fat and saturated fat, but less iron, zinc, calcium, vitamin C, vitamin B12 and fibre than traditionally weaned infants. However, energy intake was similar (Morison et al., 2016).

Aside from the New Zealand studies, only one other study has examined detailed nutrient intake of infants following a modified baby-led or standard approach. A RCT of infants in Turkey compared iron intakes and serum iron from 280 infants (BLW: n = 142, TSF: n = 138). No differences were found between weaning groups at 12 months of age for serum markers or iron consumption (Dogan et al., 2018). Iron intake from complementary foods was 7.97 mg in the BLW group and 7.90mg in the spoon-feeding group, compared to the Turkish RDA for 12 months of age set at 11mg. However, parents were advised on giving iron-containing foods and were given help with recipes and nutrition education, thus the results reflect what is offered when parents are well supported, not what might be occurring in a general population.

Given the sparsity of research in this area, coupled with concerns regarding nutrient intake expressed by health professionals, the aim of this final study was to conduct a detailed examination of infants following a baby-led or traditional introduction to solid foods, using a three-day weighed diet diary.

Specifically, the aims were to compare whether overall energy, macronutrients and micronutrients differed between the two weaning approaches, alongside a cross sectional analysis of infants at the start (6 – 8 months) and end (9 – 12 months) of the weaning process. This study was designed to contribute data to research questions:

R3. Are there differences in energy intake between weaning groups?
R4. Are there differences in macro/micronutrient intake between groups?
R5. Is BLW sufficient or significantly different to traditional weaning?

Methodology

Design

A three day weighed food record was chosen for the dietary assessment in this study as it is considered the most accurate and detailed assessment method in nutrition research (Bingham et al., 1994; Bingham et al., 1995; Prentice et al., 2011). This approach is also used in respected studies such as the UK National Diet and Nutrition Survey as it is seen as the gold standard in measuring energy and nutrient intake (PHE, 2019).

Weighed food records or diet diaries are completed over a number of days, often 3-7, by participants taking part in a study. Each item to be eaten is recorded and weighed before being offered, and then the process repeated with any leftover food or drink, to provide an accurate picture of what is actually ingested rather than simply offered. From this record, an assessment of the caloric and nutrient content of the diet is made by using dietary analysis software or nutrient tables, which list the amounts of macro and micronutrients per 100g allowing intake to be calculated from the amount of food consumed.

Weighed food records are considered an accurate measure of energy intake and are used as a comparison tool to measure the reliability of other measures of dietary assessment such as Food Frequency Questionnaires and 24 hour recalls (Bingham et al, 1997). They have been validated as being comparable to physiological measures of energy intake such as the doubly-labelled water method (Burrows et al., 2010), where participants are given an oral dose of stable isotopes such as deuterium, followed by repeated analysis of their metabolites in urine samples over several days to give an accurate measurement of energy intake. However, although this method is not a burden to participants, it is more costly to administer than a weighed food diary and requires access to laboratory facilities.

Weighed records are considered reliable because they measure the actual intake of a food, usually over several days, providing repeated measures and thus taking into account natural variation in intake over time. However, three days is typically sufficient for infant food diaries because most infants have less complexity in their diet compared to adults, meaning there is less within subject variability but more between subject variation (Lanigan, Wells, Lawson, Cole, & Lucas, 2004).

Multiple day weighed food records have been used in a number of studies examining nutrient intake in infants. For example, the DARLING study in California (Dewey, Heinig, Nommsen, & Lonnerdal, 1991) used a 4-day weighed food record, while a study of iron intake in New Zealand infants and toddlers used a 3-day weighed record (Soh et al., 2002). The randomised controlled BLISS trial comparing the intake of baby-led versus traditionally weaned infants also used this approach, highlighting its acceptability to measure intake for both self and spoon fed infants (Daniels, Taylor, Williams, Gibson, Fleming, et al., 2018; Daniels, Taylor, Williams, Gibson, Samman, et al., 2018; Williams Erickson et al., 2018).

However, as with all approaches, there are limitations to this method of dietary assessment. It is of course vital that the participant receives education on the correct way to use any scales and care is taken to record the correct amounts of food and any leftovers remaining. Most participants are capable of following such guidance (Gleason, Harris, Sheean, Boushey, & Bruemmer, 2010), although the research does rely on parents being motivated to give accurate measurements over the three days. This can be burdensome for respondents, especially when caregivers are having to feed their children many times a day.

Because of this burden, misreporting and other inaccuracies may occur. Indeed in this study there was a high rate of non-completion in terms of number of diet diaries distributed to those that were returned. However, those that were returned were complete.

Participants

Parents of an infant aged 6 – 12 months took part in the study. The study was open to either parent of the infant, and there was an option for both parents to share completion if they shared feeding of the infant. However in each case, only one primary caregiver in each family completed the study.

Inclusion criteria for participants were that they were 18+ years old, living in the United Kingdom and had already started the weaning process. Infants were excluded for prematurity (gestation <37 weeks), low birth weight (<2.5kg) and multiple food allergies, failure to thrive or other complex health issues that might affect diet.

Ethical considerations

Approval for this study was granted by the Swansea University Department of Psychology Research Ethics Committee. All participants gave informed consent prior to inclusion in the study. Ethical considerations were made with respect to the principles for research on human subjects outlined in the World Medical Association Declaration of Helsinki. As such, all subjects were provided with information about the study and were informed regarding their consent and the anonymity of their data and responses.

The study pack sent to parents contained a detailed information sheet explaining the study procedure alongside information on how participation was entirely voluntary and that participants could withdraw from the study at any point. It also explained how data would be anonymised and no individual would be identifiable from any reports. Participants were given research contact details to ask any further questions, including contact details for the supervisory team. On agreeing to take part, participants signed a consent form.

In planning the study, consideration was given to the time needed to complete the study and the resulting burden on parents, especially given the intense nature of parenting an infant of this age. Participants were reassured that if they found the study too time consuming or difficult they could withdraw at any point.

Finally, to show appreciation for the effort of the parents who took part, a gift of baby books was given to participants on completion. This was considered to be a suitable gift to note appreciation, but not of such value that it would attract participants who might be reliant on money and/or may not complete the study accurately.

Measures and procedure

Participants were recruited by placing adverts for the study on social media sites such as Facebook parenting groups and Twitter, and sharing was encouraged to spread the link to as many people as possible. If participants wished to take part, they were advised to contact either the researcher or supervisor via email (both University and personal addresses were used in the course of the study) or personal Facebook messenger app. If a parent displayed interest in taking part, the researcher sent them information on what the study entailed and asked the respondent to reply if they understood the study protocol and wanted to take part. If the parent replied positively, the researcher sent a study pack containing a set of scales, study information, consent form and return postage for the completed study pack.

Using social media for recruitment was a technique previously used to optimise the reach of surveys in a non-personal and indirect manner. The benefits and limitations of using online recruitment techniques have been discussed in chapter three.

Participants completed a questionnaire including demographic background and details of method of introducing solid foods, alongside a three-day weighed food diary for their infant.

The questionnaire (see appendix 2) included:

- Parent demographic background: age, gender, education, employment and marital status
- Infant characteristics: gender, age in weeks and parent reported weight (birth and current)

- Method of introducing solid foods: identification with weaning approach, proportion of pureed foods offered, and proportion of spoon feeding

Participants were asked how they identified with the following statement in terms of how closely they were following a baby-led method of introducing solid foods: strictly, loosely, not at all:

"BLW is the process of placing foods in front of your baby and letting them feed themselves – picking the food up themselves and putting it in their mouths unassisted, rather than being spoon-fed by a parent. This could involve them using a spoon themselves. Baby-led weaning tends to involve offering the baby family foods rather than offering pureed foods".

This self-identification was then verified by asking two follow up questions on how they approached feeding their infants:

"When your baby is in your care, how would you describe the method of feeding?"

Spoon fed by an adult
Predominantly spoon feeding, very occasional baby-led feeding
Mostly spoon-fed by an adult, some baby led feeding
About half spoon feeding by an adult and half baby-led feeding
Mostly baby-led feeding, some spoon-feeding by an adult
Predominantly baby-led, very occasional adult spoon feeding
Baby-led feeding

"When your baby is in your care, how would describe the type of food they eat? Finger foods refer to non-pureed foods in their whole form e.g. a piece of toast, pasta shape, cooked broccoli spear."

Pureed food or baby rice etc
Predominantly pureed food, very occasional finger food
Mostly pureed food, some finger foods

About half purees and half finger foods
Mostly finger foods and some purees
Predominantly finger foods, very occasional pureed food
Finger foods

Based on the combination of these two answers it was decided to split parents into two groups: those following a strict baby-led weaning approach and those using a traditional approach. This decision was made because there was no clear differentiation in proportion of spoon and puree use between those who identified using a loose BLW or traditional approach. Most tended to use both spoons and purees around half to some of the time, suggesting more of a difference in ideology compared to actual behaviour. In addition, given that the UK Department of Health do recommend giving purees alongside finger foods, all those who identified as loosely or not following a baby-led approach fitted the definition of 'traditional' weaning. Conversely those who identified as following a strict baby-led approach were clearly different, rarely using spoons or purees. This issue is considered in more depth in the general discussion. This approach of using just two weaning groups also maximised the power of the study without having to recruit larger numbers of parents to an intense research design.

For the weighed diet diary, parents were asked to weigh and note all of the foods they gave their baby over three selected days, which did not have to be consecutive. Although no specific instructions were given regarding which days to use, parents were asked not to complete diaries when their child was at day care due to the practical limitations for childcare workers completing the diary, introduction of another participant into the research study, and risk of inaccuracies between different individuals completing the diaries.

To complete the weighed food diary, parents were provided with portable scales (Salter Arc 1066, accurate to 1g). These scales were chosen because they are lightweight enough to be put in a bag if the participant was eating out of the house, but also had sufficient accuracy for the study needs. This type of scale was used in previous research such as the BLISS study (Cameron et al., 2015). Other, more accurate scales to less than <1 g are available but these are expensive, more difficult to transport, and that level of detail was not deemed necessary for this study.

To record each entry, parents were given detailed instructions about how to weigh each food offered and how to record the brand (if any), type of food, how it was prepared and the consistency: pureed, mashed, chopped or whole (see example diet diary in appendix 3). This entry sheet was adapted slightly from the BLISS protocol.

Participants were asked to record for each item of food:

- Time of day
- Name of food/drink
- Cooking method
- Weight of plate
- Weight of plate plus food
- Consistency of food – pureed, mashed, diced or whole
- Who put food into the child's mouth – adult, child or both
- Weight of plate plus leftovers
- Estimation of how much is left on the plate

To ensure that an accurate amount consumed rather than just offered was recorded, parents were asked to weigh any leftovers after their baby had finished their meal, ideally including food that had fallen on the floor or contained in a baby's bib and deduct this from the amount offered. For example, parents reported that 30g of avocado was offered but 5g remained.

This however can be complicated if a baby has been offered a number of foods at the same time, for example yoghurt, bread and fruit as a baby left to self-feed might have mixed these leftover items together on their plate or tray. In these case parents were asked to weigh individual foods if possible, but if this could not easily be done, participants were instructed to weigh the foods together and estimate the amount of each food remaining. For example, if 20g strawberries and 20g avocado were offered, and 25g was leftover, but the parent estimated half the strawberries and most of the avocado had been left, intake would be calculated as 10g strawberries and 5g avocado.

Parents were also asked to note any drinks they gave their baby, including breast or formula milk in this category. For formula and other drinks parents were asked to report the volume consumed. For breastmilk, as it cannot be accurately measured, participants were asked to report duration of feeds. As above, parents were asked to note time of day, brand of drink (if relevant), amount offered and amount left over.

Data Analysis

Measuring intake

Diet diaries were analysed using Nutritics dietary analysis software (Nutritics Professional Plus v5.099, 2020). Nutritics is proprietary software used by nutritionists, dieticians and food scientists to assess the nutrient content of individual diets and is also used to create nutrition labels for the retail food industry. It uses multiple official nutrition databases, such as the UK COFIDS including McCance and Widdowson 7th edition, 2015. Food items can either be entered individually or the database contains standardised meals, for example, "beef stew", which can be used if there is limited information from the participant on the constituents of a dish. The database contains both generic and branded food items, which are entered into the system, which generates an average daily macro and micronutrient intake report for each person.

When analysing the diet diaries, the food listed by the parent was entered into the Nutritics database, and the total amount eaten was calculated by the researcher by subtracting any leftovers from the amount offered. For example, porridge made with 20g porridge oats and 100ml whole milk. In the event that the food was not listed in the database, as was the case for some branded baby-foods, the researcher manually created a new database entry using the manufacturer's standard nutrition labelling, including calories, carbohydrates, protein, fats, sugars, fibre, sodium and other nutrients if stated.

For homemade meals that included mixing numerous foods together in cooking, parents were asked to supply a recipe. If this was done, the recipe was manually entered using standard ingredients listed in the Nutritics database, such as pasta, tomato sauce, courgettes and ham, for example. When a recipe was not stated, the researcher used the standard meal function in the Nutritics database, such as homemade tomato and vegetable pasta sauce and homemade beef lasagne. The closest description was therefore used. Clearly, the nutritional data from these meals is not as accurate as it might have been if the participant had given their own recipe, but given the small quantities of foods often eaten by infants and the similarity of many common, family-style recipes, this was an acceptable substitute.

Measuring breastmilk intake

One challenge in measuring infant energy and nutrient intake is how to establish how much breastmilk an infant has consumed. This is complicated by infants having different speeds of milk consumption (including between different feeds), women producing milk with varying fat content, and breast milk changing in energy density over the course of a day (Mitoulas et al., 2002). Comparatively, measuring formula intake is relatively simplistic.

A number of methods have been developed to try to estimate breast milk consumption. For example, accurate measuring of breast milk intake can be carried out by test weighing, which involves babies being weighed before and after nursing to gauge the amount of milk taken from the breast (Dewey et al., 1991), but this places a large burden on the mother and is impractical if outside the home environment. It also only computes volume of milk consumed and does not account for differences in energy volume in milk.

Another option is stable isotope measurement: isotopes are administered to the mother and urine or saliva samples are taken from the mother and baby to measure how quickly the isotopes leave the mother's body and appear in the infant over a period of time (IAEA, 2010). However, this method is expensive, invasive, time consuming and impractical for many research situations.

Based on these impracticalities, a more common method in more recent research is to estimate intake using infant age, number of breast feeds and the duration of feeds and compare these figures to those that have used more complex measures such as combining test weighing and number of feeds to estimate volume per feed (Dewey, Finley, & Lonnerdal, 1984; Paul, Black, Evans, Cole, & Whitehead, 1988) or combining isotopes with test weighing (Dewey et al., 1991; Heinig, Nommsen, Peerson, Lonnerdal, & Dewey, 1993a, 1993b) to calculate typical average infant intake by age. Indeed, the US Feeding Infants and Toddlers Study (FITS) (Devaney et al., 2004) used the isotope figures produced by Dewey et al (1991) and Heinig et al (1993) in the DARLING study to estimate breast milk intake based on infant age.

The BLISS study in New Zealand also used the estimates of breast milk intake calculated in the DARLING study using infant age and the isotope method to estimate breast milk for infants in their trial (Daniels et al., 2015). They used the DARLING study average figures for infants aged 6, 9 and 12 months old to estimate breast milk intake for infants of 7 and 12 months in their study, representing earlier and later stages of introduction to solid foods, reflecting the two periods that the WHO use to recommend average energy intake for solid foods (196 kcal and 455kcal per day respectively).

Given the similarities between the diet diaries used in the BLISS study and this study, the decision was made to use the same baseline figures from the DARLING study to calculate an average for each age group used. For 6-9 months this was calculated as 708g per day, while for 9-12 months, estimated intake was 547g. These amounts were entered into the Nutritics dietary analysis software for each day of the study. For those consuming formula as well as breast milk, the amounts of formula given were subtracted from the estimated breast milk intake and two separate amounts were entered into Nutritics. For those solely consuming formula, the quantity and brand used were entered into the software. It is recognised that this method has limitations and infants will vary slightly in their intake and this is considered in detail in the discussion, especially in relation to calculating overall energy intake.

Analysing intake

A report for the average intake over three days was generated for the following nutrients:

- Energy (kcal)
- Carbohydrate
- Protein
- Fat
- Saturated fat
- Fibre
- Sugars
- Sodium

- Calcium
- Iron
- Zinc
- Vitamin D
- Folate
- Vitamin B12
- Vitamin C

These nutrients were chosen as they were either nutrients of concern highlighted by health care practitioners in previous research, such as iron and zinc, or had been investigated in previous research on BLW and diet (Daniels et al., 2015; Rowan and Harris, 2012; Williams Erickson et al., 2018)

Where possible intakes were examined in relation to Reference Nutrient Intakes using WHO or UK SACN (Scientific Advisory Committee on Nutrition) infant intake recommendations. However for infants under age 2, there are no official recommendations for carbohydrates, sugar or fibre (or fats below 5 years of age) due to lack of data on optimal intakes.

Where available, intake was therefore compared in relation to the RNI. The RNI is the average daily intake of a nutrient sufficient to meet the needs of 97.5% of a healthy population. Values vary according to age, gender and physiological states such as pregnancy or breastfeeding. The Lower RNI (LRNI) is the amount needed by just 2.5% of a population, therefore the RNI was used in this analysis. Intake was also considered in relation to the Estimated Average Requirement (EAR). The EAR for energy or a nutrient is the mean intake that a group of people will need. About half of a defined population will usually need more than the EAR, and half less.

As described above, participants were divided into two groups: strict BLW and Traditional Weaning, depending on their answers to questions regarding feeding practices. Infants were also split into two age groups: 6 – 9 months (representing the earlier weaning period) and 10 – 12 months (representing the later weaning period). It was important to analyse these two groups separately because as infants progress through the weaning period they start to reduce the amount of milk feeds whilst increasing the amount of energy and nutrients they need from solid foods (WHO, 2003).

Sample size

The initial plan when designing the study was to analyse data from three weaning groups as per previous chapters: strict BLW, loose BLW and traditional weaning. However, as data collection progressed, it was recognised that two main groups were emerging as described above: those following a strict BLW approach and another more mixed group either predominantly spoon-feeding or using some finger foods but not predominantly BLW. Given the time burden on participants and this being the final stage in a four study PhD, this strategy was considered acceptable. It would allow initial differences to be identified and provide rationale for a potential larger study. This sample size is also a similar size to other research of a similar kind and very similar to one of the New Zealand studies (Morison et al., 2016).

Due to the nature of the data collection, the number recruited who followed a traditional or mixed weaning strategy was higher than those using a strict BLW approach. A core reason for this was the continued issue of interested participants stating that they were following BLW but in reality, using purees and spoon feeding as a significant part of the diet.

Statistical analyses

Statistical analysis was performed using SPSS v. 25 (IBM). First, any demographic differences between the two groups were identified using ANOVA or Chi Square. Aside from milk feeding style, as discussed in the results section, the only difference that was identified between the two groups was age of introduction of solid foods and therefore this was controlled for throughout analyses. MANCOVA were then used to compare energy, macronutrient intake and micronutrient intake between the two weaning groups, with separate analyses for the two age groups (6 – 9 and 9 – 12 months). It is recognised that subgroup analyses may not be sufficiently powered due to overall sample size and should be treated with caution.

Analyses were conducted considering intake from solid food alone followed by intake combining both solids and milk foods. This was important as milk should continue to be a major part of infant diet, but the infant should also be receiving energy and nutrients from solid foods too, increasing as they move through the weaning period.

Results

Eighty-seven study packs were sent out between September 2017 and May 2019. Seventy-one were returned complete and included in the study, while sixteen were either not returned or returned without being completed and therefore excluded from the study. All participants who completed the study were mothers. Participants had a mean age of 32.8 years (SD: 5.0), ranging from 22 to 43 years of age. Infants in the study ranged from 27 to 52 weeks of age, with a mean age of 40 weeks (SD 7.9), 35 were female and 36 male. Overall 26 infants were being introduced to solids in a strict BLW manner, while 45 were being weaned traditionally. Further sample demographic details are shown in table thirty nine.

In terms of the two age groups, in group one (26 – 39 weeks), 14 infants were following BLW and 21 TW. In this group 20 were male and 15 were female. In group two (40 – 52 weeks) 12 infants were following BLW and 24 TW. In this group 16 were male and 20 were female.

Table 39: Participant demographic information: whole sample

		Whole sample		**BLW**		**Traditional**	
Indicator	**Subgroup**	**N**	**%**	**N**	**%**	**N**	**%**
Maternal age	18-24	3	4.2	2	7.7	1	2.2
	25-29	16	22.5	3	11.5	13	28.9
	30-34	24	33.8	10	38.5	14	31.1
	35-39	22	31.0	8	30.8	14	31.1
	40+	6	8.5	3	11.5	3	6.7
Education level	No qualifications	0	0.0	0	0.0	0	0.0
	GCSE	2	2.8	1	3.8	1	2.2
	A Level	11	15.5	5	19.2	6	13.3

	Degree or equivalent	23	32.4	7	26.9	16	35.6
	Postgraduate or equivalent	35	49.3	13	50.0	22	48.9
Marital status	Married	49	69	17	65.4]	32	71.1
	Widowed	0	0.0	0	0.0	0	0.0
	Divorced	0	0.0	0	0.0	0	0.0
	Separated	0	0.0	0	0.0	0	0.0
	Living with partner	22	31	9	34.6	13	28.9
	Single	0	0.0	0	0.0	0	0.0
Employment status	Full time	4	5.6	-0	0.0	4	8.9
	Part time	14	19.8	4	15.4	10	22.2
	Maternity leave (will return)	40	56.3	15	57.7	25	55.6
	Maternity leave (won't return)	7	9.8	2	7.7	5	11.1
	Not working	6	8.5	5	19.2	1	2.2
		0	0.0	0	0.0	0	0.0

No significant difference was found in maternal age [t (68) = .918, p = .362], education [X^2 (3, 71) = .907, p = .861], marital status [X^2 (1, 71) = .253, p = .615] or employment status [X^2 (4, 71) = 8.552, p = .068] between the two weaning groups using either an independent t-test or Chi Square test.

For the whole sample of infants, Chi Square tests found no significant association between gender and weaning group [X^2 (1, 71) = .801, p = .371]. There was also no significant difference in infant age between weaning groups at the time of study completion when assessed with a t-test [t (69) = -.528, p = .599].

Turning to infant weight, there was no significant difference between weaning groups at either age group. In age group 1 (26-39 weeks), the strict BLW group had a mean weight of 8.6 kg, while the TW group weighed an average of 8.5 kg [t (27) = .322, p = .750]. In the older group (40-52 weeks), the mean weight of the strict BLW group was 9.6kg while the TW group mean was 9.8kg [t (26) = -.555, p = .584]. None of the infants was underweight according to the WHO centile charts for age/weight.

However, a t-test for a significant difference in age of introduction to solid foods was found between the two groups. For the whole sample infants in the baby-led group were introduced to solid foods at a mean age of 25.4 (SD 1.5) weeks compared to 24.3 (SD 2.8) weeks in the traditional weaning group, [t (67) = 2.008, p = .049].

With regard to milk feeding style, for the whole group: 49 infants were breast fed, 12 were formula fed, 8 were fed used mixed methods, 1 used expressed breast milk and 1 infant had been moved to cow's milk (52 weeks old), as shown in table forty.

Table 40: Milk feeding style by weaning group

	Total	Strict BLW		Traditional Weaning	
		N	*%*	*N*	*%*
Breast feeding	49	23	88.4	26	57.8
Formula feeding	12	2	7.8	10	22.2
Mixed feeding	8	1	3.8	7	15.6
Expressed breast milk	1	0	0.0	1	2.2
Cow's milk	1	0	0.0	1	2.2
Total	**71**	**26**	**36.6**	**45**	**63.4**

Within the BLW group, 23 mothers were breast feeding, 2 used formula and 1 used mixed feeding. In the TW group, 26 were breastfeeding, 10 used formula and 7 used mixed methods. Excluding the two infants fed using expressed breast milk and cow's milk, when comparing milk feeding methods using a chi square analysis, there was a significant association between milk feeding style and weaning group: X^2 (2, 69) = 6.205, p = .045. Although there was a difference in milk feeding styles between weaning groups, this was not controlled for, as the intake of milk was specifically taken into account as part of the three day diet diaries and reported as a part of the whole diet.

<u>Nutrient and energy intakes</u>

Differences in energy and nutrient intake for baby-led and traditionally weaned infants were compared separately for the two infant age groups. Two separate analyses were conducted; one for intake from solid foods only and one comparing intake when both solid and milk feeds were combined together.

Nutrient and energy intakes from solid food only

The analyses in this section only considered energy and nutrient intake from solid foods.

Age group 1: 26-39 weeks

The intake of 35 infants was considered in this analysis: 14 BLW and 21 traditionally fed. Table forty shows the mean energy intake from solid foods only in the two weaning groups. This also shows the WHO recommended intake from solid foods in this age group and the percentage of infants who consumed within 10% of this amount. Differences between the two weaning groups were analysed using a MANCOVA, controlling for timing of introduction to solid foods.

Looking at energy from solid foods exclusively in table forty one, there was a significant difference between the two weaning groups, TW infants were consuming 137% more calories than BLW infants [F (1,33) = 18.235, p = .000]

Table 41: Energy from solid foods at 26-39 weeks and as a percentage of WHO recommendations

		Mean intake (SD) in kcal	**Range (kcal)**	**Significance**	**WHO EAR**	**Within 10% WHO EAR**
Solid food	*BLW*	119.7 (70.4)	30.4 – 305.0	F (1,33) = 18.235, p = .000	196 kcal	0 (0%)
	TW	284.6 (132.0)	56.0 - 631.0			2 (9.5%)

Table shading denotes significance at p < 0.05

The average intake in the BLW group did not meet WHO recommendations for intake from complementary foods, whilst the average for infants in the TW exceeded this. However, there was a large difference in range between infants. Intake in the BLW had a range from 30.4 to 305.0 kcal and the traditional group ranged from 56.0 to 631.0 kcal. Due to the wide variability seen in calorie intakes, intakes within 10% of the WHO recommended amount were noted. Only 2 or 9.5% of the TW group had intakes within 10% of 196 kcal, while none of BLW group were close to this amount.

Table 42: Nutrient intake from solid foods only at 26-39 weeks

	Strict BLW Mean (SD)	TW Mean (SD)	RNI	Significance
Carbohydrate g	14.9 (10.9)	39.4 (21.0)	No RNI <2yrs	F (1, 32) = 10.841, p = .002
Protein g	4.8 (3.5)	11.9 (6.4)	12.7-13.7*	F (1, 32) = 12.453, p = .001
Fat g	4.5 (2.1)	9.0 (4.2)	No RNI <5yrs	F (1, 32) = 7.966, p = .008
Saturated Fat g	1.6 (.9)	3.2 (1.8)	No RNI <5yrs	F (1, 32) = 5.273, p = .028
Sugar g	5.5 (5.5)	14.0 (8.5))	No RNI <2yrs	F (1, 32) = 7.514, p = .010
Free Sugars	.7 (1.0)	2.2 (2.3)	No RNI <2yrs	F (1, 32) = 2.625, p = .115
Fibre g	2.0 (1.2)	4.5 (2.0)	No RNI <2yrs	F (1, 32) = 12.268, p = .001
Iron mg	.7(.5)	1.7 (1.0)	4.3-7.8*	F (1, 32) = 10.982 = .002
Zinc mg	.5 (.3)	1.0 (.6)	5*	F (1, 32) = 4.389, p = .058
Sodium mg	139.1 (100.4)	217.5 (132.6	320*	F (1, 32) = 2.232, p = .145
Calcium mg	61.1 (67.4)	159.3. (122.8)	525*	F (1, 32) = 7.005, p = .013
Vitamin D mcg	.2 (.2)	.5 (.5)	8.5-10^	F (1,32) = 5.688, p = .023
Vitamin C mg	10.5 (10.5)	12.9 (9.6)	25*	F (1, 32) = .146, p = .705
Vitamin B12 mcg	.3 (.4)	.6 (.5)	.3-.4*	F (1, 32) = 2.134, p = .154
Folate mcg	18.7 (14.4)	34.6 (25.6)	50*	F (1, 32) = 2.611, p = .116

Table shading denotes significance at p < 0.05

**Dependent on age*

^Safe intake

There were statistically significant differences in nutrient intakes between the two groups as shown in table thirty eight above. TW infants consumed more carbohydrate [F (1, 32) = 10.841, p = .002], fat [F (1, 32) = 7.966, p = .008], fibre [F (1, 32) = 12.268, p = .001], and protein [F (1, 32) = 12.453, p = .001], than the BLW infants. However, these can in part be explained by differences in overall intake between the two groups. If the overall food intake is higher, levels of different macronutrients in that food will also be higher i.e. the TW group took in 18% more energy than the BLW group, leading to an expectation that they would also have an 18% higher intake of macronutrients.

For micronutrient intake, iron was higher in the traditional group [F (1, 32) = 10.982 = .002], although neither group met the RNI for iron consumption of 7.8mg for infants 7-12 months: the RNI being the amount of a nutrient that is enough to meet the needs of 97.5% of a group. However, a significant proportion of nutrients would still be expected to come from milk (breast or formula) in this age group, so the results are not surprising. Calcium and vitamin D intake were also higher in the traditional group ([F (1, 32) = 7.005, p = .013] and [F (1,32) = 5.688, p = .023] respectively), although also not close to the RNI.

Age group 2: 40-52 weeks

The intake of 36 infants was considered in this analysis: 12 BLW and 24 traditionally fed. Table forty three shows the mean intake for infants in the two weaning groups. Differences between the two weaning groups were analysed using a MANCOVA, controlling for timing of introduction to solid foods.

Table 43: Energy from solid foods at 40-52 weeks and as a percentage of WHO recommendations

		Mean intake (SD) in kcal	**Range (kcal)**	**Significance**	**WHO EAR**	**Within 10% WHO EAR**
Solid food	*BLW*	324.3 (151.7)	107 - 546	F (1,34) = 1.065, p = 0.309	455 kcal	1 (8.3 %)
	TW	379.4 (150.6)	80 - 614			5 (20.8%)

Energy intake solely from complementary foods in the older age group was not significantly different between weaning groups [F (1,34) = 1.065, p = 0.309], with the traditional weaning group having a slightly higher (16%) intake but neither group met the WHO recommendation of 455 kcal. When proximity to this recommendation within 10% was checked, only 1 (8.3%) of the BLW group and 5 (20.8%) of the TW group met the criteria.

Again, this was probably due to the wide range of average energy intake in this age group, which was 80 kcal to 614 kcal (seen in the TW group), with a whole age group mean of 361kcal. In contrast, the strict BLW group kcal intake ranged from 107 to 546 kcal.

Table 44: Nutrient intake from solid foods only at 40-52 weeks

	Strict BLW Mean (SD)	TW Mean (SD)	EAR/RNI/ RNI	Significance
Carbohydrate g	41.5 (19.9)	52.7 (20.4)	No RNI <2yrs	F (1, 32) = 1.701, p = .202
Protein g	12.7 (5.6)	16.0 (6.2)	13.7-14.9*	F (1, 32) = 1.397, p = .246
Fat g	12.0 (6.5)	13.3 (6.0)	No RNI <5yrs	F (1, 32) = .069, p = .795
Saturated Fat g	4.6 (2.5)	5.2 (2.4)	No RNI<5yrs	F (1, 32) = .192, p = .644
Sugar g	16 0 (11.0)	21.9 (8.8)	No RNI<2yrs	F (1, 32) 2.654, p = .113
Free Sugars	1.7 (1.8)	1.8 (1.9)	No RNI<2yrs	F (1, 32) = .006, p = .939
Fibre g	5.0 (2.7)	6.0 (2.7)	No RNI<2yrs	F (1, 32) = .418, p = .523
Iron mg	1.7 (.9)	2.4 (1.7)	7.8*	F (1, 32) = 1.402, p = .245
Zinc mg	1.5 (.8)	1.6 (.9)	5.0*	F (1, 32) = .000, p = .988
Sodium mg	303.5 (125.2)	294.9 (148.1)	350*	F (1, 32) = .189, p = .677
Calcium mg	156.5 (95.9)	245.4 (170.6)	525*	F (1, 32) = 1.846, p = .184
Vitamin D mcg	.5 (.5)	.9 (1.1)	8.5-10^	F (1, 32) = 2.020, p = .165

Vitamin C mg	19.5 (16.3)	23.4 (19.4)	25*	F (1, 32) = .113, p = .739
Vitamin B12 mcg	.8 (.5)	.9 (.7)	0.4*	F (1, 32) = .002, p = .967
Folate mcg	54.3 (34.5)	47.9 (35.6)	50*	F (1, 32) = .702, p = .409

**Dependent on age*

^Safe intake

Although there were differences between groups as shown in table forty four above, none reached significance. Intake of all nutrients was higher in the TW group, probably due to higher energy intake, except for sodium and folate, which were slightly higher in the BLW group.

<u>**Nutrient and energy intakes from solid food and milk (breast or formula)**</u>

Age group 1: 26-39 weeks old

The intake of 35 infants was considered in this analysis: 14 BLW and 21 traditionally fed. Table forty five shows the mean energy intake for infants in the two weaning groups. Differences between the two weaning groups were analysed using a MANCOVA, controlling for timing of introduction to solid foods.

Table 45: Energy intake from solid foods and milk at 26-39 weeks

		Mean intake (SD) in kcal	Range (kcal)	Significance	WHO EAR	Within 10% WHO EAR
Solid food + milk	*BLW*	618.4 (93.6)	473.0 – 800.0	F (1,33) = 12.704, p = .001	682 kcal	6 (43%)
	TW	729.5 (88.2)	549.0 – 859.0			9 (43%)

Table shading denotes significance at $p < 0.05$

When energy intake from both milk and complementary foods was calculated, there was a significant difference between groups, with the TW group consuming 1.2 times as many calories as the BLW group [F (1,33) = 12.704, p = .001].

The range of three-day average energy intake in this age group was 473 to 859 kcal (age group mean of 685 kcal), with the strict BLW group ranging from 473 to 800 kcal and the traditional group ranging from 549 to 859 kcal. These ranges were narrower than those seen when complementary foods only were assessed, and this was reflected in a higher proportion of the groups having an intake within 10% of the WHO energy recommendation: 6 infants (43%) in the BLW group and 9 (43%) in the TW group.

Table 46: Nutrient intake from solid foods and milk at 26-39 weeks

	Strict BLW Mean (SD)	**TW Mean (SD)**	**EAR/ RNI**	**Significance**
Carbohydrate g	65.1 (13.7)	85.9 (15.3)	No RNI <2yrs	F (1, 32) = 12.425, p = .001
Protein g	14.3 (3.8)	20.6 (5.7)	12.7-13.7*	F (1, 32) = 11.902, p = .002
Fat g	33.5 (3.4)	34.1 (5.1)	No RNI <5yrs	F (1, 32) = .220, p = .642
Saturated Fat g	15.2 (1.4)	14.6 (3.0)	No RNI <5yrs	F (1, 32) = .069, p = .794
Sugar g	55.3 (9.2)	56.8 (11.3)	No RNI <2yrs	F (1, 32) = 1.384, p = .248
Free Sugars	.7 (1.0)	2.2 (2.3)	No RNI <2yrs	F (1, 32) = F (1, 32) = 2.625, p = .115
Fibre g	2.4 (2.0)	5.3 (2.4)	No RNI <2yrs	F (1, 32) = 9.888, p = .004
Iron mg	1.6 (1.5)	3.6 (2.1)	4.3-7.8*	F (1, 32) = 6.792, p = .014
Zinc mg	2.8 (.9)	3.5 (1.0)	5*	F (1, 32) = 2.889, p = .099
Sodium mg	246.9 (101.8)	325.7 (127.9)	320*	F (1, 32) = 1.993, p = .168
Calcium mg	323.4 (116.2)	427.4 (152.8)	525*	F (1, 32) = 3.612, p = .066
Vitamin D mcg	1.1 (3.4)	2.7 (3.3)	8.5-10^	F (1, 32) = .954, p = .336

Vitamin C mg	42.1 (17.7)	50.4 (18.2)	25*	F (1, 32) = 1.088, p = .305
Vitamin B12 mcg	.4 (.6)	.9 (.8)	.3-.4*	F (1, 32) = 2.057, p = .161
Folate mcg	59.0 (27.8)	74.4 (35.0)	50*	F (1, 32) = 1.088, p = .305

Table shading denotes significance at p < 0.05

**Dependent on age*

^Safe intake

Looking at total nutrient intake from both milk and complementary foods in table forty six, there were several significant differences between the weaning groups in this younger age group. The TW group had higher carbohydrate [F (1, 32) = 12.425, p = .001], fibre [F (1, 32) = 9.888, p = .004] and protein [F (1, 32) = 11.902, p = .002] intakes which might be expected with a higher energy intake. However, fat intake was not significantly different between the groups [F (1, 32) = .220, p = .642], which suggests a higher proportion of energy intake was derived from fat in the strict BLW group. Iron intake was also significantly higher in the TW group, which had an intake over twice as high as the BLW group [F (1, 32) = 6.792, p = .014]. However, neither group met the RNI for iron of 4.3mg (6 months) to 7.8mg (7-9 months). No other nutrient intake was significantly different between groups, and intake for all other nutrients was higher in the TW group. Both groups met the RNI for vitamins C, B12 and folate.

Age group 2: 40-52 weeks old

The intake of 36 infants was considered in this analysis: 12 BLW and 24 traditionally fed. Table forty seven shows the energy intake for infants in the two weaning groups. Differences between groups were analysed using a MANCOVA, controlling for timing of introduction to solid foods.

Table 47: Energy intake from solid foods and milk at 40-52 weeks

		Mean intake (SD) in kcal	Range (kcal)	Significance	WHO EAR	Within 10% WHO EAR
Solid food + milk	*BLW*	715.4 (153.8)	489-893	F (1,34) = 0.151, p = 0.700	830 kcal	6 (50%)
	TW	736.7 (155.3)	462 - 995			9 (38%)

When energy intake from both milk and complementary foods was calculated for the second age group, there was no significant difference between groups, with the TW group consuming just 3% more calories than the BLW group [F (1,34) = 0.151, p = 0.700], as shown in table forty seven. The range of three-day average energy intake in this age group was 489 to 995 kcal, with the strict BLW group ranging from 489 to 893 kcal and the traditional group ranging from 462 to 995 kcal. There was less variability in this age group when milk intake was included, with a higher proportion of the groups having an intake within 10% of the WHO energy recommendation achieved by 6 infants (50%) in the BLW group and 9 (38%) in the TW group.

Table 48: Nutrient intake from solid foods and milk at 40-52 weeks

	Strict BLW Mean (SD)	TW Mean (SD)	EAR/ RNI	Significance
Carbohydrate g	77.3 (27.4)	89.8 (21.1)	No RNI <2yrs	F (1, 31) = 1.848, p = .184
Protein g	20.0 (6.0)	22.7 (6.2)	12.7-13.7*	F (1, 31) =.895, p = .352
Fat g	34.6 (6.4)	33.2 (7.4)	No RNI <5yrs	F (1, 31) = .181, p = .673
Saturated Fat g	15.0 (2.4)	14.5 (3.3)	No RNI <5yrs	F (1, 31) = .080, p = .779
Sugar g	55.3 (12.2)	59.9 (12.7)	No RNI <2yrs	F (1, 31) = 1.214, p = .279
Free Sugars	1.7 (1.8)	1.8 (1.9)	No RNI<2yrs	F (1, 31) = .006, p = .939
Fibre g	5.6 (3.2)	6.6 (3.5)	No RNI <2yrs	F (1, 31) = .220, p = .642

Iron mg	2.7 (2.0)	3.8 (2.5)	7.8*	F (1, 31) = 1.071, p = .309
Zinc mg	3.6 (1.5)	3.5 (.9)	5*	F (1, 31) = .155, p = .696
Sodium mg	392.3 (122.7)	374.0 (143.8)	320*	F (1, 31) = .411, p = .526
Calcium mg	368.4 (146.5)	462.5 (176.9)	525*	F (1, 31) = 1.863, p = .182
Vitamin D mcg	1.8 (3.1)	2.7 (2.9)	8.5-10^	F (1, 31) = .493, p = .488
Vitamin C mg	49.4 (29.7)	51.3 (23.3)	25*	F (1, 31) = .000, p = .987
Vitamin B12 mcg	1.0 (.9)	1.1 (.7)	.3-.4*	F (1, 31) = .029, p = .865
Folate mcg	88.7 (40.1)	82.7 (38.3)	50*	F (1, 31) = .509, p = .481

**Dependent on age*

^Safe intake

Taking into account both milk and solid foods, there were slight differences between groups but none reached significance, as shown in table forty eight, above. The TW group had a higher intake of most nutrients except fat (and saturated fat), zinc, sodium and folate.

Iron intake was again higher in the traditional weaning group than BLW group (3.8mg vs. 2.7mg), but not significantly so [F (1, 31) = 1.071, p = .309], and neither group met the RNI of 7.8mg. In addition, neither group met the RNI for zinc, calcium or vitamin D but both groups met the recommended intake for protein, sodium, vitamin C, B12 and folate and intake of sodium was not at unhealthy levels.

Discussion

Using a three-day weighed diet record, this study examined differences in the energy and nutrient intake of babies aged 6 to 12 months depending on their weaning approach. Composition of both complementary foods only and the entire diet (breast or formula milk and complementary food) were compared for infants introduced to solids using strict baby-led weaning and the traditional method of spoon-feeding with additional finger foods from six months, as recommended by the UK Department of Health.

Overall, the findings showed several key significant differences in energy, macro and micro nutrients for infants aged between 6-9 months of age but no significant differences in intake for infants were 9-12 months of age. This suggests that potentially although differences in energy and nutrient intake might be present at the start of weaning, they disappear as infants become more competent and start eating a larger proportion of solid foods in their diet. Notably, differences occurred more when considering solid foods alone compared to the cumulative intake from solids and milk together. This suggests that it is important to consider the whole diet, especially given that infants who are self-feeding and breastfeeding appear to have a slower move over to a solid food diet. However, it is clear that parents may need further support to ensure their infants are consuming micronutrients, iron in particular. Taken together, these findings have important considerations for health professionals supporting parents through the transition to solid foods.

Energy intake

When considering an infant's diet it is important to recognise that breast or formula milk should still play an important part in contributing to energy and nutrient intake. In this study, breast milk intake was estimated to be 708ml per day in the 6-9 month age group and 547ml in the 9-12m group. This would result in a calorie intake from milk of approximately 490kcal in the younger age group and 380kcal in the older age group, or about 72% of kcal in the younger age group and 46% in the older group. Thus at the start of the weaning process, milk will still contribute a large proportion of nutrients, with a reduction over the next six months. This transition should be gradual, making sure the infant is introduced to new foods and textures, but not at such a rate that milk is replaced at too fast a rate. Therefore it is important to consider an infant's overall diet both in terms of milk and complementary foods.

When looking at energy from complementary foods alone, mean intake between the two weaning groups in the 26-39 weeks age group was significantly different: 119.7kcal in the strict BLW group compared to 284.6kcal in the traditional weaning group, meaning that the TW group was consuming just over twice the calories of the strict BLW group from complementary foods. Considering this in light of recommendations for infants of this age, the World Health Organisation recommends that infants age 6-8 months in developed countries require an average of 196kcal from complementary foods each day (WHO, 2003).

Although this will depend to some extent on the development and weight of an individual child (and those in the BLW group were slightly heavier, although not significantly, than those in the TW group), these results suggest that on average infants weaned using a strict BLW approach were eating under the recommended guideline for complementary foods at the start of the weaning process, while TW babies were eating more than recommended. However the range of intakes matters too. Infants in the BLW group ate between 30 to 305 kcal a day, compared to 56 to 631 kcal in the TW group, suggesting a high degree of variability between infants during early weaning. This is supported by the low percentage of infants with an energy intake around that recommended by the WHO, as seen in tables forty and forty-two. Overall, infants weaned using BLW may on average be starting their transition to solid foods a little too slowly, and traditionally weaned may be too fast, but there is convergence by the time they are 9 – 12 months old.

When both solid foods and milk were considered together, the difference between the two groups was smaller yet still significant. Traditionally weaned infants (mean 730 calories) were on average still consuming more than the recommended 682 calories by the WHO, whilst BLW were consuming under this with a mean of 618 calories – although around half were within 10% of WHO EAR. Taken together, the strict BLW group's intake was 85% of that of the TW group, compared to 42% when looking solely at complementary foods, suggesting that strict BLW babies were consuming a greater proportion of their energy from milk compared to TW babies, which might be a contributing factor to the slightly higher weight seen in younger BLW infants.

Comparatively, no significant differences were found in energy intake between weaning groups for infants aged 9 – 12 months, either for solid foods alone or milk and solid foods taken together. Considering solid foods alone, the BLW group consumed 324kcal or 85% of the amount that the TW group ate and 715 kcal or 97% of the calories of the TW group for milk and solids combined. Both groups were therefore consuming less than WHO recommendation of 455 kcal from solids alone and 830 calories from both solids and milk for infants of 9-11 months (WHO, 2003) but again the majority were within healthy weight ranges.

Similar research has shown that infants may eat at levels below recommended intakes. For example, in the BLISS study, infants were consuming on average 860 kcal at 12 months (854 for TW and 866 for BLW) compared to WHO recommendations of 1092 for infants 1-3 years still being breast-fed (Taylor et al., 2017; WHO, 2003). This suggests that there may be discrepancies between what is recommended and what is normal for infants in these samples, given there was no report of growth faltering in either this study or by Taylor et al (2017).

Given the process of introducing solid foods to infants should be gradual, with an emphasis on continued milk particularly in the early months, and culminating at around 12 months, the findings highlight how BLW may support a more gradual transition, reducing the risk of overconsumption of energy, or reduction in milk which still provides significant nutrients and in the case of breastmilk, antibodies and other protective factors (Andreas, Kampmann, & Mehring Le-Doare, 2015).

Considering the impact of differential calorie intake upon potential weight, no differences occurred in this study and most infants remained a healthy weight at this stage (at least based on parental reported weight). The findings suggest that infants in the traditional weaning group may be on an initial trajectory to overweight due to increased calorie intake but this was reduced in the latter part of weaning in this small sample. Given some studies show a difference in weight between TW and BLW in larger samples (Brown and Lee, 2015; Jones et al., 2020; Townsend and Pitchford, 2012) it would be interesting to explore this further.

Reflecting on the findings that energy intake of BLW infants being lower than TW and the WHO EAR, it is also possible that overall intake of BLW infants is being underestimated due to a higher proportion being exclusively breastfed. Intakes of breastmilk were estimated, using validated measures used in other studies. However, no study has validated breastmilk intake this way amongst babies who are following BLW – it is possible it differs compared to infants who are breastfed but spoon-fed. The studies that were used to validate breastmilk intake against test weighing or isotopes were conducted before the concept of BLW existed in its modern definition. Further research may wish to explore this.

Considering whether these findings are in line with previous research, there is little literature available describing energy intake of infants weaned using BLW. However neither Morison et al (2016) or Taylor et al (2017) reported significant differences in energy intake between groups. In both studies, spoon fed infants consumed fewer calories overall than the TW infants in our study for both solids and milk and solids combined, whilst BLISS BLW infants consumed more than our BLW infants. This difference may be explained by methodological differences. BLISS randomised parents to each arm whereas this study followed parental choices in a population. When parents are left to choose their method, it could be that infant or parent characteristics drive feeding approach. Potentially, the higher consumption amongst BLW in the BLISS study could also be explained trial protocol to offer infants higher fat foods every day.

<u>Macronutrient intake</u>

Examining macronutrient intake, several differences occurred between the two groups but these disappeared once milk was also included.

Looking at the significant differences in macronutrient intake from solid foods only between the two groups, the TW group consumed more carbohydrates, protein, fat, saturated fat, sugar and fibre at 6 – 8 months compared to the strict BLW group. However, when this was examined in relation to overall higher calorie intake in the TW group, only the intake of fat was proportionately different. The strict BLW group consumed 42% of the calories of the TW group, 38% of the carbohydrates, 40% of the protein but 50% of the fat, suggesting that the strict BLW group ate a greater proportion of their solid food calories from fat.

For both milk and solids together, at 6 – 8 months the TW group consumed more carbohydrates and protein, with the strict BLW group consuming 76% of the carbohydrates of the TW group and 69% of the protein. However, the BLW group had a fat intake which was 98% of that of the TW group, demonstrating they were eating a higher proportion of fat in their diets. This could be attributed to a higher milk content in the diets of strictly BLW infants; breast and formula milk have relatively high fat contents compared to many weaning foods (approximately 4.1g/100g and 3.4g/100ml respectively). This reflects findings from the BLISS study where BLW infants ate more total fat at 7 months of age (Williams Erickson et al, 2018; Morison et al, 2016).

Another reason for the difference in fat intake could be variation in the types of foods infants consumed. In the previous chapter, it was identified that those following a TW approach ate more commercially prepared composite meals designed for babies, whilst BLW infants are more likely to join in family meals, as demonstrated in previous research (Brown and Lee, 2011a; Rowan and Harris, 2012). Commercial infant meals tend to be higher in sugars and starchy carbohydrates but lower in fat compared to average family meals (Crawley and Westland, 2017). This increase in fat in the BLW group might there be a consequence of eating 'adult' family foods such as salmon, cheese, spaghetti bolognaise, chips, and cake for example, which could also be a consequence of health professional concerns that infants may not eat enough energy if parents are using BLW (Cameron et al., 2012a; D'Andrea et al., 2016), prompting parents to potentially offer higher fat foods. Indeed, in the BLISS study, the protocol was designed to meet these concerns, encouraging parents to offer higher healthy fat foods every day. This should not be seen as a negative finding, given the small amounts involved and the importance of fats in growth and development (Huffman, Harika, Eilander, & Osendarp, 2011; Uauy and Dangour, 2009). And again, there were no differences by 9-12 months of age

In the previous study, infants following a BLW approach were offered more protein foods but fewer dairy foods than the TW. It is interesting to consider why these differences might have emerged in that study but not in this study. Potentially differences may occur in a larger sample, but this might also represent the difference between what is offered (the previous study) and what is consumed (the current study). Parents may perceive that because they are offering a food their infant is consuming a wide variety of nutrients, but of course consumption and the characteristics of those who took part are important variables.

Considering whether these findings are in line with previous research, there is little literature available describing specific nutrient and energy intake of infants weaned using BLW. However, one study from New Zealand looking at the intakes of infants aged 6-8 months from both milk and complementary foods using different weaning methods (full BLW, partial BLW and Traditional spoon feeding) (Morison et al., 2016), reported no significant difference in energy intake between groups. TW infants consumed 692 kcal (2897 kJ) as opposed to 730 kcal in our younger age group, and the full BLW group had an intake of 669 kcal (2800 kJ) compared to 618 kcal in our study. Neither result was significantly different. The full BLW group also had lower intakes of protein, carbohydrates and fibre but higher intakes of total fat and saturated fat when compared to the spoon-feeding group. So this reflects our findings that fats contributed a higher proportion calories than protein and carbohydrates in BLW infants.

The New Zealand BLISS group found that at 7 months, total energy intake from milk and solid foods was 684 kcal (2862 kJ) in the control group (TW) and 716 kcal (2996 kJ) in the BLW intervention group, which was not significantly different. This is compared to 730 kcal in our younger TW group and 618 in our BLW group. Intake from complementary foods only was 161kcal (672kJ) in the TW group and 191 kcal (799kJ) in the BLISS group, compared to 285 kcal in our TW and 120 kcal in our BLW group – meaning that our TW group was eating substantially more complementary foods in early weaning than the BLISS TW group, and our BLW group was eating less than the BLISS BLW group.

At 12 months, energy intake was 854 kcal (3573 kJ) for the TW group and 866 kcal (3623 kJ) in the BLW group, which was not significantly different. Again this did not reflect the findings for our older study group, where the TW group consumed 750 kcal and the BLW group had 715 kcal. Meanwhile intake for complementary foods only was 574 kcal (2400 kJ) in the TW group and 604 (2527 kJ) in the BLISS group, compared to 395 kcal in our older TW group and 324 kcal in our BLW group. The quantity of complementary foods eaten was therefore much lower in our study, compared with the BLISS study.

These results are possibly due to the interventional nature of the BLISS study, which encouraged parents using BLW to give high energy foods to their infants each day. This was because of concerns raised by health care professionals when baby-led weaning became more visible and popular among parents as was demonstrated in the first study in this thesis and another from New Zealand (Cameron et al., 2012a). In addition the larger sample in the BLISS study may have led to greater variation between results.

Micronutrient intake

Moving to micronutrient intake, a number of differences arose between the two groups in the younger age group, although significant differences had disappeared by 9-12 months.

For both solids alone and milk and solids together, iron intake was significantly lower in the strict BLW group in infants aged 26-39 weeks: 0.7mg vs 1.7mg for solid foods only and 1.6mg vs. 3.6mg for milk and solids. The difference between the figures incorporating milk could be due to increased use of iron-fortified formula in the TW group, although both of the groups consumed less than the RNI of 4.3mg (infants of 6 months) to 7.8mg (infants of 7-12 months). Given the importance of iron intake from complementary foods in this age group, it would seem prudent for parents to offer iron-rich foods daily to infants as iron stores gained in utero and by maternal transfer at birth are depleted. Infants weaned using a strict BLW model are fed iron-fortified cereal (a common weaning food) less often than traditionally weaned infants (Fu et al., 2018; Morison et al., 2016). However, it should be noted that even the traditionally weaned group had a low iron intake of 1.7mg/day, and the non-haem iron in infant cereal is not very absorbable (Hurrell and Egli, 2010; Monsen, 1988).

As shown by these results, when considering differences between weaning groups, it is important to consider the influence of milk. A greater proportion of BLW infants (24 out of 26) were breast fed, which would have had an effect on the results of the "whole diet" analysis. When looking at iron intake by milk feeding style, independent of weaning group, average intake for those being formula fed or those being fed with a combination of breast and formula milk was close to current recommendations of 4.3mg (4-6 months) and 7.8mg (7-12m), while those infants breast feeding had intakes considerable lower than the RNI in both age groups. Thus, the results suggest that in this sample, most iron consumed was coming from formula rather than complementary foods.

However, iron deficiency anaemia (IDA) is rare in developed countries such as the UK, with approximately 3% of infants, aged 5-11 months affected (Lennox A, 2013). This could be because differences in iron *intake* do not necessarily equate to differences in iron *absorption*. Infant formula is fortified with iron to levels above those seen naturally in breast milk: 5.3mg/L in one leading UK milk (Aptamil, Nutriticia Ltd) compared to 0.2-0.9mg/L in human milk (Lonnerdal and Hernell, 1994). However, absorption of iron from breast milk is estimated at 49% (Saarinen, Siimes, & Dallman, 1977), which is much higher than the absorption from formula, estimated at around 12% (Saarinen and Siimes, 1977).

It is also important to consider the whole diet consumed. Including meat, fish and poultry foods in a mixed meal, increases the absorption of any non-haem iron present by 50% in one study (Engelmann, Sandstrom, & Michaelsen, 1998; Monsen, 1988), while phytates (found in whole grains) inhibit absorption, as does calcium (Hurrell and Egli, 2010). Although this study did not look at phytates in the diet, the lower dietary calcium in the strict BLW group may have a positive impact on their iron absorption. In the previous research outlined in chapter five, strictly BLW infants were also offered protein foods such as meat or beans more often than TW infants at 6-8 months, alongside fewer dairy products. In addition, in this study vitamin C intakes were well above the RNI for both weaning groups, and this increases non-haem iron absorption.

Although obtaining serum iron levels from participants was outside the scope of this thesis, none of the infants in the BLISS study displayed IDA, even though iron intakes in both the BLISS and control groups were below RNI levels, which highlights the complexity of iron intake and serum iron status (Daniels, Taylor, Williams, Gibson, Fleming, et al., 2018).

More research is needed concerning the iron status of infants using BLW in the UK, but there are important implications in these findings. Although parents should be reassured that although IDA is relatively unusual, it would be prudent to offer iron-rich and nutrient-dense foods often when using baby-led weaning, rather than relying on fruit and vegetables in the early days. As suggested in chapter three, the study of health and child care professionals' attitudes to BLW, a booklet containing recipe suggestions (e.g. lentil patties and pancakes made with iron-fortified cereals) and advice on suitable weaning foods could be given to parents interested in using BLW with their infants, as well as those choosing traditional methods since these infants also had iron intakes below the RNI. This would be a relatively cheap and easy to produce resource which could be distributed to health visitors across multiple Clinical Commissioning Groups (CCGs), maximising reach among new parents.

Moving onto other nutrients, although a significant difference was only found between weaning groups for solid foods only at 26-39 weeks, both groups had a very low vitamin D intake. This underlines the official UK Department of Health advice to supplement all breastfed infants with 8.5-10mcg vitamin D from birth, and all children from 12 months to 4 years of age (10mcg) (SACN, 2016), because of the lack of sunlight exposure in the UK and small amounts present in food. For example, a boiled egg contains 1.6mcg, 100g baked salmon contains about 6mcg, 10g polyunsaturated spread contains 0.8mcg and 30g fortified breakfast cereal contains 1.4mcg. However, whether a small child would eat enough of the foods naturally highest in vitamin D (such as oily fish) is debatable. The body makes vitamin D in response to UVB light but the UK only receives enough light for most people to make enough vitamin D in the summer months, and people with darker skin tones may not respond to these levels, which underlines why supplementation is particularly important in these populations, who may be more at risk of deficiency diseases such as rickets (SACN, 2016; Webb, 2006).

Calcium intake was also significantly lower in the strict BLW group at 26-39 weeks, compared to the TW group, at 61mg vs 159mg, compared to the RNI of 525mg, but differences disappeared when the whole diet including milk was included in the analysis. However, levels were still well below recommended intake. As was mentioned in the discussion of chapter four, dairy (and consequently calcium) consumption being lower in infants weaned in a baby-led manner may be a consequence of the method itself, as parents using BLW consistently tend not to use spoon-feeding which means they do not offer calcium rich foods such as yoghurts and fromage frais often. Parents may need to be reassured that offering their baby spoons of yoghurt a few times a week to ensure adequate calcium intake is unlikely to negate the benefits of a baby-led introduction to solids if carried out responsively, for example by watching for signs of fullness like the infant turning their head away and stopping feeding when these signs are observed. Advice like this could be added to educational materials that could be given to parents by HCPs, but it is also important to emphasise that as responsive feeding is key for infants, whether a parent is using a spoon or following child-led feeding.

For other nutrient intakes in the younger age group, for which the differences were not significant, the strict BLW group had a lower intake than the traditional group, probably due to the lower energy intake in this group. However, neither weaning group met the RNI for zinc and the strict BLW group was slightly low in sodium. Intakes for vitamin C, B12 and folate met dietary guidelines, which is reassuring.

In the older age group, there were no significant differences in micronutrient intake, either for complementary foods alone or for the whole diet, although consumption of zinc, vitamin C and B12 was lower (although similar) in the strict BLW group, again probably due to the lower energy intake. Intakes of sodium and folate were slightly higher in the strict BLW group when solid foods were considered alone, although not significantly so.

These findings reflect the limited existing research available on nutrient intakes in infants weaned using BLW, although findings have been mixed. While Morison et al (2016) found lower iron intake in BLW infants, Williams Erickson et al (2018) did not. However, both studies found infants were consuming below recommended levels. Although the BLISS study protocol recommended an emphasis on iron intake, other markers of iron intake and storage such as plasma ferritin and iron-deficiency anaemia were also not significantly different (Daniels, Taylor, Williams, Gibson, Fleming, et al., 2018). It is notable that the protocol did not increase iron intake much higher than the TW group; potentially parents in this age group find it difficult to offer their infant sufficient quantities of iron rich food regardless of approach.

When the New Zealand-based BLISS research group looked at iron intake, they found that the difference in iron intake between the modified-BLW (n = 105) and control groups (n = 101) at both 7 and 12 months was not significant. At 7 months, intake from complementary foods only was 1.2mg in the BLISS (BLW) group and 1.0mg in the control group (TW), compared to an intake from foods of 0.7mg in the strict BLW group and 1.7mg in the TW group, in our study. However, when milk was taken into account, the BLISS BLW group had an intake of 3.0mg at 7 months, while the control group had an intake of 2.7mg. At 12 months, the intake from complementary foods in the BLISS study was 3.2mg for both groups, while for our 9-12 month group intake was 1.6mg for the strict BLW group and 2.4mg for the TW group.

Conversely, a recent RCT from Turkey comparing 142 BLW infants and 138 traditional spoon-fed (TSF) infants 6-12 months of age found that at 12 months iron intake from complementary foods was 7.97mg in the BLW group and 7.90mg in the TSF group, which was not significantly different (Dogan et al., 2018). Hematologic markers were also similar. However, it should be noted that again parents who were randomised to the BLW group had received advice on high-iron and energy-dense foods and recipes (as well as foods known to be a choking risk), so this was a modified form of BLW similar to that used in the BLISS protocol. This aside, it does raise the question of why iron intake was so much higher in this Turkish study compared to those from New Zealand and the UK. There may be potential differences in the foods offered by Turkish parents for cultural reasons, for example food seen as suitable for weaning may well include meat, fish, eggs and iron-containing plant foods such as lentils and chickpeas, which are common in Mediterranean diet patterns (Trichopoulou et al., 2014). Parents in these studies may also have used iron-fortified infant cereal to make BLW-friendly pancakes or allowed some spoon feeding. Further comparative research would be interesting as it is unclear what specific foods were offered and the differences are stark.

For other micronutrients, Morison et al (2016) found lower levels of zinc, calcium, vitamin C and B12 in their BLW group compared to the traditionally weaned group, although our younger BLW group only consumed significantly less calcium and vitamin D. Conversely, the BLISS study found no significant difference in zinc intake and status at 7 or 12 months (Daniels, Taylor, Williams, Gibson, Samman, et al., 2018), similar to the results of this study.

<u>Limitations</u>

It should be stated that there were some limitations to this study. The sample used was self-selecting and, in all likelihood, a highly motivated cohort. Other methodological limitations regarding sampling are discussed in chapter three. In addition, most were white, married and well-educated and the study was cross sectional, rather than a randomised trial, meaning that other factors associated with method choice could have influenced diet. However, no significant differences in demographic background were found between the groups.

One limitation to highlight is the possibility that this study was underpowered due to the low number of participants, particularly in the BLW group. Recruitment for this study did not aim to secure a large sample size in part because it was the fourth study in a doctoral thesis but also because of the intense nature of the data collection. Due to this not being a funded study participants were not paid for their time and therefore recruitment had to rely on the good will of a smaller number of interested participants. The groupings were then further hampered by the self-identification of participants who initially stated they were using BLW but on closer examination in became apparent they were using a hybrid approach. This led to two groups rather than three being used, and resulted in a smaller number of strict BLW infants.

However, the sample size did reflect that used in similar exploratory published research that used weighed food diaries (also conducted by a postgraduate student) in New Zealand (Morison et al., 2016). Additionally given this was the first study to use a weighed diet diary to explore the intake of BLW infants in the UK, this data provides a useful start to further work that will hopefully examine this issue with a larger sample in future.

A further limitation, as mentioned in chapters five and six is the analysis of individual age groups rather than using a 2 x 2, weaning group x age group design. Again, although this design was chosen because of the difference in what infants eat at the start and end of the weaning process, a secondary analysis using a multifactorial design could be carried out in future research.

Other limitations include possible participant error or inaccuracy in measuring or recording foods, a perennial issue in dietary assessment studies (Bingham et al., 1994; Schoeller and Westerterp, 2017). In addition to these methodological limitations, the infant self-feeding in BLW generates a unique situation with food being dropped, squashed and spread around a child's eating area. This creates an issue for parents when weighing leftovers, and may have contributed to over or under estimation. It should also be noted that some parents omitted to supply recipes for home-made meals, in which case meal recipes were chosen from the Nutritics database, which may have altered intake to some degree. However, the researcher was available to answer queries and communicated with participants to help with issues around weighing and measuring food to minimise inaccuracies.

An aspect of this ability to freely communicate with study participants which may have limited the scope of the study, was the use of private email and messenger apps. Using

Facebook messenger was an easy way for the parties to communicate as some recruitment was via Facebook posts which were shared across groups and personal/professional networks. However, this meant the participants were not blinded to the researcher's identity (and vice versa), which may have introduced bias.

The use of a Facebook group to inform participants about the study and correct procedures for carrying out the diet diary for example, was considered and although it would have made communicating with respondents less time consuming, it may have introduced partiality into parental reporting of their child's diet if they had seen what other parents were feeding their child, due to social acceptability bias or potential guilt for not providing the "right" foods. In retrospect, a series of YouTube videos detailing how to use the food scales and fill in the food diary could have been created to help parents with common issues and save time for the researcher in answering repetitive queries. This would be implemented in any further studies to help participants complete diet diaries accurately.

A further limitation is the possibility that breast milk intake was over or under-estimated, particularly in baby-led weaned infants, as it is likely they up-regulated their due to a slower transition to solids. Although the method used to estimate breast milk intake was described by Dewey et al (1991) and also used by the BLISS team, other methods such as doubly labelled water and post-feed weighing are more accurate. However, these methods were outside the scope of this thesis. Future research is warranted to more accurately measure the milk intake of infants weaned in this manner.

In addition, the study relied on a nutrition database (Nutritics Ltd), which may have included unintentional errors. However, Nutritics is updated regularly and widely used by nutrition processionals including those working in the labelling of commercial food products, which require highly accurate data. As discussed, one particular limitation related to database use is the current omission of free sugars from fruit juices and purees on infant food labels, which means that sugar consumption was undoubtedly underestimated.

In spite of these limitations, this is the first study of its kind in the UK to look at a weighed food record and detailed nutrient intake of babies weaned using a strict form of baby-led weaning. It highlights that few differences occur in nutrient intakes between baby-led and traditionally weaned infants, especially in the later stages of weaning and underlines the adequacy of dietary intakes among babies weaned using BLW. It does highlight that all parents may need further support particularly around offering nutrient-dense and especially iron-rich foods, regardless of weaning approach.

Chapter 8: General Discussion

This thesis set out to explore the dietary intake of infants using a baby-led approach to the introduction of solid foods, compared to those following traditional weaning practices. Using four interlinked studies, incorporating different methods and participants, it examined the attitudes and concerns of health and child care practitioners towards the baby-led weaning method alongside measuring the eating behaviours and food and nutrient intakes of infants aged 6-12 months following different weaning approaches. Figure 1 below is a schematic representation of the studies.

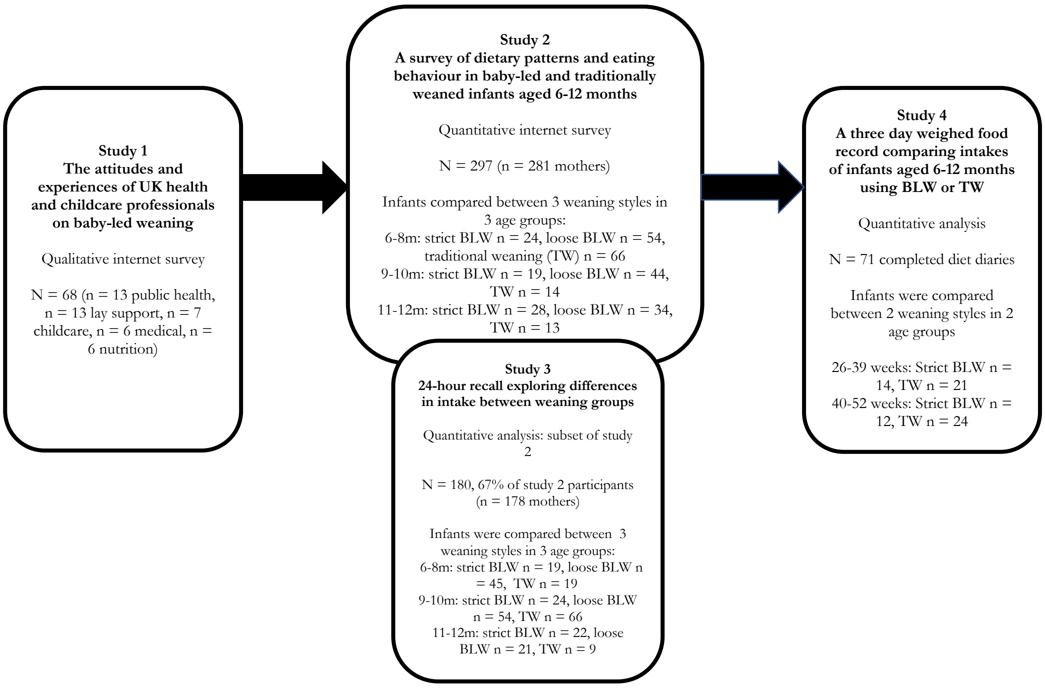


Figure 4: Schematic of studies within the thesis

Initially, the thesis highlighted concerns amongst health professionals that infants following baby-led weaning (BLW) would not consume sufficient energy or nutrients. However, data collected from parents using the approach challenged this. Overall, infants following baby-led weaning were perceived as less fussy than their spoon-fed peers, and were exposed to a wider variety of foods, particularly vegetables and protein. In terms of nutrients and energy consumed, analyses found that towards the latter stages of weaning, no real differences were seen in intake dependent on weaning style. However in earlier stages, baby-led infants had a slower introduction to solids, consuming less energy from complementary foods than spoon-fed infants, who consumed almost 2.4 times the energy and consequently, had a significantly higher intake of many nutrients. Given the importance of milk in an infant's diet and that the transition to solid foods should be gradual, BLW could play an important part in managing this process with consideration given to ensuring sufficient energy consumption and that all 'finger foods' are not treated equally. Taken together, the findings of this thesis add to an important and growing area of research exploring early nutrition.

Bringing the findings together

At the start of this thesis, a preliminary study explored health and childcare professionals' concerns regarding the baby-led method of introducing solid foods. The findings of this study underpinned three further research questions focusing on a central issue raised in study one – that of infant nutrient and energy intake according to weaning style. Three further interlinked studies examined these questions incorporating survey data and measurements of dietary intake. Different methods were used to balance sample size with intensity of task, to give multifaceted insight into the core question of 'does weaning style affect infant dietary intake?' Data from the four studies is synthesised below to examine the research questions in detail.

1. What are the concerns about dietary intake and weaning style?

Following on from similar research in New Zealand (Cameron et al., 2012a), an initial survey of health and childcare providers in the UK explored their experiences and concerns around the baby-led method. This provided insight into existing knowledge gaps and underpinned the direction for the next stages of the thesis. Overall, professionals provided a variety of views, identifying both positive and negative aspects with many perceiving the impact of the approach to be dependent on the individual baby and family. Caution was raised around simply promoting the method, with the requirement of considering how it could be interpreted by families living in different contexts.

The vast majority of respondents (93%) recognised potential benefits to BLW, such as greater food acceptance through reduced fussiness and appetite self-regulation for the infant, as well as improved motor skills and increased family meals. However, 76% also identified problems such as potential reduced energy and nutrient intake, as well as practical issues around mess, cost and possible safety concerns regarding choking and the use of inappropriate foods. These themes reflect research that has explored practitioners views in other countries such as New Zealand and Canada (Cameron et al., 2012a; D'Andrea et al., 2016), suggesting commonalities in views and concerns, and highlighting the need to explore these issues in further research. Critically, a third of participants expressed a desire for more research on BLW to reassure them of its safety and sufficiency and increased training, as many stated they felt ill-equipped to advise parents, particularly as there was no official guidance from the Department of Health. This desire for a wider evidence base for the safety and efficacy of BLW had also been expressed by professionals in the aforementioned studies (Cameron et al., 2012a; D'Andrea et al., 2016).

Existing quantitative research into the impact of baby-led weaning has tended to focus on infant weight and growth (Dogan et al., 2018; Jones et al., 2020; Taylor et al., 2017; Townsend and Pitchford, 2012) or choking risk (Brown, 2018; Fangupo et al., 2016). Relatively little research has examined what baby-led infants are consuming particularly in terms of micro and macronutrients. Given this research gap and the specific concerns of those supporting parents with weaning, this thesis set out to detail the eating behaviours and dietary intake of babies weaned using different methods, to build an evidence base supportive of health professionals and parents introducing complementary foods.

Exploring nutrient intake in more depth was an important issue given its potential impact upon health and weight. Although infants would be receiving nutrients from breast or formula milk, these alone can no longer meet the energy or nutritional needs of a growing infant and complementary foods must be added to the diet, in particular to provide sufficient energy to fuel growth, as well as iron, since stores transferred from the mother during pregnancy and birth are depleted (Michaelsen, 2003; SACN, 2018). Health professional concerns focused on the infant not being able to self-feed sufficient food to support growth, while others raised the idea of infants avoiding foods they did not like, meaning a lower variety of foods being consumed, particularly iron rich and nutrient-dense foods. It was clear that some professionals believed infants needed to be spoon fed pureed foods, which shows the impact of introduction of this type of method of feeding babies over the last century. Historical research shows that until approximately 1920 most infants were given family foods at around 10 months of age (Bentley, 2014). The concept of special baby foods and spoon feeding is the novel 'new approach' – not baby led weaning.

However, other professionals held the alternate view that baby-led weaning would promote a more regulated intake of food leading to a healthier weight gain, or rather that spoon-feeding could lead to lower self-regulation and an excess intake. The belief that BLW leads to a healthy weight trajectory is supported partially by research examining the eating behaviours of BLW infants. Although findings are mixed, it has been proposed that baby-led weaning may encourage greater satiety responsiveness as infants have greater control over their food intake (Brown & Lee, 2015). It could therefore be expected that infants who are more satiety responsive consume a diet that reflects their individual energy requirements, hence the need to explore this in relation to self-feeding during the weaning process.

This begs the question, from the viewpoint of a nutrition or health professional looking at the potential differences in infants weaned using different methods: which is worse for the child's long-term health: to be an overweight, traditionally weaned infant or an underweight baby-led weaned infant?

Although it seems counter-intuitive at first glance, an underweight infant who is self-feeding may be in a better situation than an overweight spoon-fed infant, for several reasons. Firstly, intentional weight loss in an infant or toddler is not supported in clinical practice, rather the goal would be to slow the rate of growth if it was deemed concerning by a clinician (Styne et al., 2017). However, even this raises ethical questions around restricting or changing the amount of food available for a child, particularly if the child is not yet mobile and therefore not able to be active. Thus, changing a child's weight trajectory from one of rapid weight gain (RWG) to a previous centile path, may be problematic in spite of its link to overweight and obesity in later life (Zheng et al., 2018).

If a TW child has become overweight and crossed growth centiles, they may have learnt to override hunger and satiety cues by being encouraged to eat more if fed non-responsively (Savage et al., 2018) or they may have been provided with an abundance of energy dense food, which could have influenced their flavour preferences and intake (Nicklaus et al., 2004; Ventura and Worobey, 2013). Given the persistence of food preferences, this is another reason why an overweight TW infant might be in a less desirable situation than an underweight BLW infant.

However, the seriousness of this hypothetical situation is very much dependent on its aetiology. There are numerous reasons why an infant may gain weight too quickly or falter, including physiological and social/environmental factors. Returning to the situation of an underweight BLW infant, they might have dropped weight due to an inability to feed well at the start of weaning but would be able to "catch up" to their previous centile when their ability to self-feed improved. This is clearly not the same as an infant who is struggling to feed themselves enough and get sufficient energy over a longer period due to the poor feeding choices of a parent who is not providing appropriate energy and nutrient-dense foods to support development. For example, a parent may not provide sufficient high energy food due to lack of education on what constitutes appropriate solid foods or out of a misguided desire to provide a "healthy" diet, but this can be easily rectified with advice from a health professional and the child should be able to resume their growth trajectory guided by their innate satiety and hunger cues.

However, failure to thrive or underweight resulting from neglect is outside of the scope of this current discussion, and it should be stated that all the infants in study three were of a normal weight, even if food intake was lower due to their milk intake probably being higher than the TW group. It is possible that for these infants, being underweight would be less of a concern than being overly reliant on milk and thus potentially missing out on nutrients obtained from complementary foods such as iron and zinc. Conversely, overweight is likely due to an excess energy intake from solid foods, particularly if breast fed because intake is highly regulated by the child (Dewey and Lonnerdal, 1986; Li, Fein, & Grummer-Strawn, 2010). Further discussion on the role of BLW in weight homeostasis is found in the section on energy intake below.

2. Does food acceptance differ between weaning groups?

To initially examine the dietary and behavioural differences in weaning groups, the second study explored differences in perceptions of eating behaviour and food preferences as well as dietary frequency in infants of 6-12 months. Given the large sample, infants were split into three groups according to weaning style (strict BLW, loose BLW and traditional spoon-feeding) and behaviours by infant age (6–8, 9–10, 11–12 months) to examine the different stages of the weaning process. Overall, the strict BLW group were perceived to be significantly less fussy, less responsiveness to food and more satiety responsive, than the traditional group. Additionally, they were perceived to enjoy their food more. These findings confirmed some of the positive beliefs raised in study one by the health and childcare professionals and challenged those who believed infants may become more picky in their eating behaviour.

However, when the transition through the weaning process was taken into account, only satiety responsiveness remained significantly higher for strictly BLW infants in each age group; no differences in fussy eating, food responsiveness or enjoyment were seen for older infants. This is interesting given that almost all studies that have explored weaning approach and fussiness conclude that BLW show reduced fussiness compared to spoon fed infants (Brown et al., 2017; Fu et al., 2018). These findings add to the literature by suggesting that when infant age is considered in smaller groups, although an effect may be seen for a whole sample, the differences may be focused in the younger age groups towards the start of weaning. This is still positive as it likely supports infants in the transition to solid foods.

There are numerous reasons why BLW may be associated with reduced fussiness towards the start of the weaning process. The younger BLW infants in our study may have been perceived as less fussy because they were also viewed as enjoying their food more than those traditionally weaned, possibly because they had greater control over their selection and intake of food. Mothers who follow a BLW approach have shown lower levels of control over their infant's intake (Brown and Lee, 2011c), while in studies with older children, a more responsive maternal feeding style lower in control has been linked to lower levels of fussy eating in children (Dovey et al., 2008; Jansen et al., 2017; Sutin and Terracciano, 2018).

Allowing babies to handle their food may also be an important element of promoting food acceptance. Part of the baby-led weaning process involves the infant playing with and exploring the foods they are eating. Squishing food in their hands, dropping some on the floor to see the dog gobbling it up and tasting a sweet piece of fruit for the first time: these are all activities that an infant feeding themselves may experience and enjoy as part of their mealtime, teaching them about the tastes, textures and properties of different foods. This active exploration and play is quite different from a child passively receiving a spoon of food at a pace they are not in control of, may offer some explanation as to why BLW infants are seen as less fussy. Indeed, research with older children finds that when they are allowed to handle or play with their food, or be involved in its preparation, they are more likely to try or accept those foods (Coulthard and Ahmed, 2017; Coulthard and Sealy, 2017; Nederkoorn, Theiβen, Tummers, & Roefs, 2018).

Eating family foods in their whole form may be another factor in the reduced fussiness of BLW infants. Research involving adults with dysphagia has found that pureed food diets have low compliance and acceptability, which has negative consequences with regard to intake and overall nutrition for those prescribed these diets (Sura et al., 2012; Vucea et al., 2018). As previously discussed, pureed infant foods have a similar, sweet bland taste and appearance as they are often based around apple, pear or sweet vegetable purees, thickened with starches or with added water (Crawley and Westland, 2017). We understand and accept that adults with dysphagia don't enjoy pureed foods, so perhaps it's not surprising that infants may not enjoy them either.

Another aspect of reduced fussiness seen in BLW infants is that of wider food variety. In study two BLW infants were offered a wider variety of foods than those being spoon-fed, particularly in terms of proteins and vegetables, while diary entries for TW infants in study four could be repetitive, with the same product being fed multiple times over several days . Increased dietary variety has been associated with decreased fussiness, although the direction of influence is unclear (Vilela, Hetherington, Oliveira, & Lopes, 2018). One explanation is that BLW infants' increased acceptance is due to the form of their foods. Potentially being able to view, handle and smell the food promotes acceptance in these infants.

However, differences in fussy eating were not identifiable amongst older age groups, and in fact perceptions of fussiness decreased for the older TW age group. Given the discussion above this makes sense. Spoon-fed infants tend to transition to more finger and family foods as they move through the weaning process, potentially becoming more accepting of foods for the reasons above. It may also be that baby-led infants simply accept new tastes sooner than spoon-fed infants. Research has shown that babies typically take up to 8–10 times to accept a new food but that research is likely to be based on spoon-feeding or pureed foods (Anzman-Frasca, Savage, Marini, Fisher, & Birch, 2012; Barends et al., 2013; Cooke, 2007; Wardle et al., 2003). Do infants eating whole foods accept them sooner?

The impact of lower levels of fussy eating and increased enjoyment of food may influence, or be influenced by, some of the differences in dietary intake seen in studies two, three and four. BLW infants were more likely to consume vegetables, which fussier infants are more likely to reject (Dovey et al., 2008; Taylor et al., 2015), while TW infants had a greater intake of commercial products and composite meals which are known to have a predominance of sweet tastes and similar flavour profiles (Garcia, Curtin, Ronquillo, Parrett, & Wright, 2020). The question arises – does BLW promote food enjoyment and acceptance through these foods offered or does infant temperament and eating behaviour lead to weaning method used? Previous research has shown that infants perceived to have a difficult temperament are more likely to be introduced to solid foods early, which must be via spoon-feeding, most likely in an attempt to settle behaviour (Brown and Rowan, 2016; Crocetti, Dudas, & Krugman, 2004). Longitudinal research is needed to explore this association and consider whether it is due to who chooses to follow BLW or whether BLW might promote acceptance of foods.

Satiety responsiveness is another important aspect of eating behaviour related to energy intake and longer-term weight gain. Greater satiety responsiveness in BLW infants compared to spoon feed infants was persistent throughout the weaning period. This adds to the mixed picture of previous research. One longitudinal study on satiety and weaning style found toddlers introduced to solids using a baby-led approach were more satiety responsive and less likely to be overweight when compared with traditionally weaned children (Brown and Lee, 2015). However, the BLISS research group found those using a modified form of BLW were less satiety responsive than a control group weaned using traditional methods (Taylor et al., 2017) and a recent study of toddlers from the UK found no difference in satiety responsiveness between weaning styles (Komninou et al., 2019).

Considering why infants who follow BLW may be perceived to be more satiety responsive, research has identified several influences on a child's satiety responsiveness in studies with older children such as parent feeding styles and the interaction between a child's genes and their eating environment (Hughes and Frazier-Wood, 2016). From a theoretical perspective, this interplay of genes and environment highlighted by Wardle in her

Behavioural Susceptibility Theory (BST) (Carnell and Wardle, 2007), and outlined in section 2.2.1 of the Literature Review in chapter two offers some insight. It suggests that the genetic differences in appetite are responsible for variations in weight seen within the same environment, so that expression of weight increases in an obesogenic environment for those who are more responsive to food cues (either internal feelings of hunger or a cake shop on the way to school) because they are more likely to overeat. How do these findings about BLW fit into this paradigm?

The CEBQ used in study two, was developed to measure some of the behaviour associated with the BST (Wardle, Guthrie, et al., 2001), and the dimensions of food responsiveness and enjoyment of eating are associated with increased weight while satiety responsiveness is associated with lower weight (Llewellyn and Fildes, 2017). In this study, satiety responsiveness was higher in BLW infants: this could mean that BLW allows internal satiety cues to be felt by the child or perhaps it could mean that those infants who are genetically more likely to be satiety responsive get on better with BLW? For example, do parents whose baby seems very hungry, give up on BLW if their child gets frustrated or fussy if they can't feed themselves quickly enough to satisfy their appetite. This is plausible in early weaning when physical coordination is still developing but may be misinterpreted by parents. Further research would be interesting to understand the characteristics and motivations of parents deciding to start BLW and if they cease using it, why? There is evidence that early introduction of solids is linked to infant appetite and size (Brown and Rowan, 2016), suggesting that parents concerned about infant weight and intake of breast milk may make decisions about weaning diet based on perceived infant behaviour, for example pressuring to eat or restricting if faced with a fussy or hungry child. For parents of fussy infants whose parents are concerned they won't grow sufficiently when using baby-led weaning, this research should be reassuring as the infants in this study were all a healthy weight.

Alternatively is it possible that the process of baby-led weaning mitigates some of the genetically determined responses to appetitive cues? If so, the direction of effect is unclear: perhaps the increased satiety responsiveness seen in study two is due to BLW dampening the obesogenic effect of the infant's environment either through parents offering less energy-dense food, which has the potential to alter food preferences that extend into older childhood and adolescence (Nicklaus et al., 2004), or as a result of the inherent responsiveness of the BLW process itself. As such it may be a valuable strategy to enhance satiety responsiveness in children who would otherwise be genetically prone to obesity (Llewellyn et al., 2014), possibly as part of an intervention for infants already on a rapid weight gain trajectory as there is evidence that BLW may mediate weight gain .

In fact the Intervention Nurses Start Infants Growing on Healthy Trajectories (INSIGHT) longitudinal RCT, based on a responsive parenting (RP) intervention to prevent childhood obesity by reducing rapid weight gain in infancy, found that infants whose mothers were in the RP arm had a reduced prevalence of overweight at 1 year and experienced slower weight gain (Savage, Birch, Marini, Anzman-Frasca, & Paul, 2016). In addition, the intervention group were more likely to follow a healthier dietary pattern at 9 months (Hohman, Paul, Birch, & Savage, 2017) and at three years they had a lower mean BMI z score and fewer were overweight or obese (Paul et al., 2018), demonstrating that there is growing evidence that responsive parenting and feeding has a positive impact of healthy weight trajectories in early childhood.

Responsive feeding, as exemplified by baby-led weaning, is attentive to a child's signs of hunger and satiety and respects their innate hunger and satiety cues. If these cues are ignored, for example when an infant turns their head away from a spoon or bottle but the caregiver encourages the child to continue eating, the child may learn their appetite for more or less food is unimportant and a habit of over (or under) eating may emerge (Black and Aboud, 2011). However, allowing a child to feed themselves, while ensuring the food available to them can meet their dietary needs, hands responsibility for how much and what to eat over to the child. Thus baby-led weaning is a highly responsive way to "feed", as it allows the child to have autonomy over their appetite. Given the link between satiety responsiveness and weight in infancy, it seems prudent to investigate ways of maintaining this internal appetite control throughout the lifecycle, particularly as poor self-regulation in early childhood has been linked with rapid weight gain during school years (Anderson, Sacker, Whitaker, & Kelly, 2017; Francis and Susman, 2009).

3. What are the differences in energy intake between groups?

A common concern of the professionals raised in study one was that infants following baby-led weaning would not consume sufficient energy due to self-feeding. Data from across the three nutrient intake studies, and in particular the diet diary in study four, paints a picture which is not straightforward, complicated by difficulties in measuring breastmilk intake and therefore accurately estimating overall energy and nutrient intake.

The three day diet diary showed significant differences in energy intake from solid foods amongst infants aged 6–8 months old, with TW infants consuming 2.4 times more kilocalories than the BLW group, although when milk intake was included the differences halved. However, variations in energy intake between groups disappeared by 9–12 months both from solid foods and milk and solids combined.

As previously outlined, the WHO recommends 196 kcal daily from solids alone and 682kcal from solids and breast milk at 6-8 months (Michaelsen, 2003). The traditional weaning group of 6-8 month infants were consuming an average of 285 kcal per day from solid foods and 730 kcal from milk and solids. Although longitudinal data was not collected, this pattern is concerning. A seemingly small excess of 50 kilocalories per day could lead to overweight longitudinally. This would fit with studies that have found spoon-fed infants are more likely to be overweight as toddlers and preschool children (Brown and Lee, 2015; Jones et al., 2020). However, the BLW infants were consuming less than WHO recommendations at 120 kcal from solid foods. When milk feeds were accounted for, energy intake increased to 620 kcal, which is also lower than recommended. Although these results would appear to validate some of the concerns in the first study that BLW infants weaned might not consume enough energy from foods to support their growth, none of the infants in the study were underweight according to WHO weight for age centiles and, according to parent-reported weights, the younger BLW infants were actually heavier than TW infants.

Looking at some of the theories behind bodyweight homeostasis, we can see how weaning styles may be viewed as part of the eating environment that interplays with the genetic traits of individual infants. Instead of the traditional "set-point" model, it is likely that according to the general model of intake our genetic tendency to be hungrier or more satiety responsive, may be impacted on by the environment, in this case, weaning method: if an infant is less satiety responsive but is weaned using BLW, the slower pace of eating may moderate potential weight gain. Likewise, in the dual intervention model, weaning method may be one of the factors that influence whether an individual's weight is at the top or bottom of their natural weight boundaries. Results of studies looking at weight in different weaning cohorts are mixed (Brown and Lee, 2015; Jones et al., 2020; Taylor et al., 2017; Townsend and Pitchford, 2012) and as yet there are no studies looking at weight trajectories in older children who were weaned using BLW. Additionally, there has been no genetic research assessing the incidence of SNPs linked to increased hunger or satiety in BLW infants. This idea for possible future research would help elucidate the direction of influence of BLW on satiety and hunger.

Looking at the large disparities in energy intake in the current study combined with the normal weights reported, it is highly likely the BLW group were getting more of their energy from milk, given all the infants were a healthy weight. It is also likely that although a validated method of estimating breastmilk consumption was used, the actual intake was underestimated. To our knowledge, studies using doubly-labelled water or post-feed weighing have not been undertaken with babies weaned using this method and it is likely breastfeeding BLW babies upregulated their milk intake.

Again, although the study was not longitudinal, it is likely infants following a BLW approach were having a slower transition to solid foods, as discussed further in question five. This gradual transition is recommended by the WHO (Michaelsen, 2003) but some BLW infants in this study appeared to be having 'too slow' a transition according to recommended intake, as none had an energy intake from complementary foods within 10% of the WHO recommendation of 196 kcal. This may also have been because the TW group started weaning earlier and were more familiar with eating solids, eating larger quantities at the time of the survey. The range of energy intakes at 26-39 weeks suggests this was the case, with the highest energy intake from solid foods in the TW group at 631 kcal compared to 305 kcal in the BLW group.

The disparity in energy intake may also be linked to the kinds of foods being offered by parents using BLW. Across studies two, three and four the BLW infants consumed more low energy foods like fruit and vegetables, compared to those being spoon-fed who ate more energy dense foods like composite meals and baby cereals. These findings are echoed in other studies examining intake (Morison et al., 2018; Morison et al., 2016). However, it is important to not focus solely on the energy content of the foods in question; nutrient density is also a concern. Commercial products may be higher in calories but also often contain fewer nutrients and higher levels of sugar than home cooked foods (Crawley and Westland, 2017; Garcia et al., 2020) (considered in more depth in question four).

There is a paucity of research on specific energy intake in BLW infants, hampered by the complications in measuring calorie intake from breastfeeding. One study from New Zealand comparing the intakes of infants aged 6-8 months using different weaning methods (Morison et al., 2016), reported no significant difference in energy intake between groups. Notably, their traditional spoon feeding (TSF) group consumed about 5% less than our TW group, while their full BLW group consumed 8% more than our strict BLW group. Looking at the BLISS data, there were large differences between our results: at 7 months their control group (traditional weaning) consumed 28% less than our comparable group, while the BLW group consumed 58% more than our strict BLW group (Williams Erickson et al., 2018). At 12 months, both BLISS groups consumed more energy from complementary foods, 45% more in their traditional group and 86% more in their BLW group. The quantity of complementary foods eaten by the BLW infants in study four was therefore much lower, compared with the BLISS study.

However the BLISS intervention gave parents advice on how to incorporate iron-rich and energy dense foods into their child's diet each day (Cameron et al., 2015). This is perhaps an element that should be considered when promoting a baby-led approach, although it must be balanced with ensuring babies do not eat too much, risking becoming overweight in the process. No difference in weight was seen between the two weaning groups in the BLISS study, potentially attributed to this guidance, whereas other studies (albeit nonrandomised) have seen a lower rate of overweight amongst baby-led infants. Further research is needed.

4. What are the differences in macro/micronutrient intake between groups?

Data from the three studies highlighted a difference in nutrient exposure and intake between the groups. Although precise nutrient intake could only be measured in the diet diary study, the food frequency and 24-hour recall data followed similar patterns in foods offered and thus the nutrients infants consumed. Although some differences were seen across the studies, in general BLW infants consumed a higher variety of vegetables and protein rich foods, also having a higher intake of fats, compared to TW infants who had a higher intake of carbohydrates (particularly sugar) and calcium-rich foods.

Examining macronutrient intake and carbohydrate first, one concern was higher sugar intake amongst TW infants. This may be exacerbated by the higher intake of commercial products such as pureed 'composite meals' consumed in the TW infant groups across studies two, three and four. Recent research has highlighted how many of these meals have a high level of sugar in them due to a predominance of sweet tastes particularly in the earlier stages of weaning. Even foods labelled as savoury often contained purees or concentrated fruit juices to improve palatability (Garcia et al., 2020), and the WHO has called for the common use of fruit purees in commercial infant foods to be addressed (WHO, 2019).

This is particularly concerning when these foods are in puree form. Although sweet fruits are valuable sources of nutrients such as vitamin C, fruit purees are digested much more rapidly than whole fruit, whose sugars are surrounded by a fibre matrix which slows digestion. Thus fruit purees act similarly to free sugars in the body, with the same potential to cause dental caries, promote excess energy intake and influence long-standing taste preferences (Mennella, 2014; Pyne and Macdonald, 2016; Skinner et al., 2002). This is why fruit purees and juices were reclassified as free sugars by Public Health England in 2018 (Swan, Powell, Knowles, Bush, & Levy, 2018). Although intake of these free sugars (added sugars, honey, and sugars from juices and purees) was low for all groups, infant food manufacturers are not currently required to classify fruit purees as free sugars, therefore these are not listed in nutrition information on food labels or provided to databases. This results in an underestimation of free sugars in the diets of infants who consume these products. In a recent study of the availability, composition and marketing of European baby foods, the WHO analysed almost 2000 infant foods and found that in just over half of products, total sugar (free sugars and intrinsic sugars) accounted for more than 30% of energy (WHO, 2019).

Another concern around carbohydrate intake is the higher intake of carbohydrate-based processed and snack foods in infants following a BLW approach, particularly those who class themselves as following a "loose" version of the method across the studies. Undoubtedly these are convenient for parents on the go, but they contain few micronutrients, unless fortified, and even then should not be overly relied on due to concerns over salt saturated fat and sugar. These ultra-processed foods are marketed as being healthy finger foods for babies, yet research has found that many baby foods contain more sugar than advertised on the labels, which can be misleading as they don't list the free sugars from pureed fruit and juices (Crawley and Westland, 2017). In addition, the loose BLW groups in studies two and three also had a higher intake of convenience foods such as chips and pizza. Again, although these foods are convenient and can be self-fed easily, commercial varieties marketed at adults and families often contain sodium levels that are unsafe for infants.

The results of the diet diary study showed the BLW infants consumed a higher proportion of their energy from fats, possibly as they were having more family foods, which included a variety of higher fat protein sources such as cheese, meats and eggs. These contain more fat than commercial purees, which tend to have a more starch-based macronutrient profile. Essential fats such as EPA and DHA are found in fish, eggs and meats and are vital for development and functioning of the brain, nervous system and cell membranes (Mahan and Raymond, 2016). In contrast, processed foods tend to contain more saturated fatty acids due to their shelf-stability, and the consequences of eating a diet high in saturated fat has been well-documented, particularly in the context of ultra-processed foods such as the snacks which were most often eaten by the loose BLW group in studies two and three (Hall et al., 2019; Kris-Etherton and Krauss, 2020). Interestingly, the BLW groups ate more cheese than the traditional group in studies two and three, while the traditional group ate more low fat yoghurt and fromage frais than the BLW groups. Although this may have reduced the TW group's intake of fat, it may have increased their intake of sugars as yoghurts can be highly sweetened (Crawley and Westland, 2017). On balance, given the high energy needs of infants in this age group, the higher fat intake of the BLW groups would be of less concern nutritionally than the high sugar intake seen in some of the traditionally weaned infants.

When looking at the findings of the studies regarding protein intake, the BLW infants consumed a wider variety of protein sources and were more likely to try these foods earlier in the weaning process than the TW group, although protein intake in the three day diary study was not proportionally higher in the BLW group. This has implications not only for potentially reduced fussiness via exposure, as protein foods are often rejected by fussy eaters (Dovey et al., 2008) but also micronutrient intake. These foods are good sources of key nutrients of interest such as essential fats, iron and zinc, and although intake of these nutrients was low across the board, if children are exposed to and accept these foods early in the weaning process they are likely to increase their intake as they grow because food preferences have been found to track into older childhood (Vilela et al., 2018).

Turning to micronutrient intake, iron was a key concern for professionals surveyed in study one. Although no significant differences were seen in iron rich foods offered in study three, intakes in study four were well below the RNI in both weaning groups, independent of age and whether intake was calculated from both solids alone or with milk. This is concerning as infants in this age group may be predisposed to iron-deficiency anaemia due to their rapid growth (Michaelsen, 2003; SACN, 2010). Iron intakes were also lower than those in the BLISS project, although the RNI was not reached in either the control or BLW groups, despite parents being encouraged to offer iron rich foods each day (Daniels, Taylor, Williams, Gibson, Fleming, et al., 2018). However, a recent study from Turkey comparing baby-led and TW infants, also recommending iron-rich foods, found intakes of both BLW intervention and control groups near the UK RNI at 12 months (Dogan et al., 2018). This may have resulted from participants accessing fortified foods and formula uncommon in the UK or New Zealand. However, plasma ferritin and haemoglobin levels in the BLISS groups at 12 months were normal, suggesting intake was adequate for these infants. This raises the question of when iron intake from food becomes a critical issue – might infants (at least with the background of those who participated in the study) be protected for longer than we think? Further research is needed.

Another notable aspect of the findings around iron intake, was the difference between those who were breast feeding and formula feeding. When iron intake was analysed independent of weaning group, breast feeding infants attained about a third of the RNI in each age group, while those formula or mixed feeding either met or just missed the RNI. However, as discussed in chapter five, the lactoferrin and transferrin present in breast milk effectively increase absorption of iron, so although the intake of these infants appears low, this may not be clinically relevant. Additionally, breast milk intake may have been underestimated due to infants upregulating their intake. Clearly, plasma ferritin or haemoglobin levels would confirm the absence of iron-deficiency but these tests were out of the scope of this thesis.

Another notable disparity in micronutrient intake was seen for calcium. Neither group met the RNI in either age group in study four, while dairy product intake was higher in the traditional group in study three, possibly because of the intake pattern mentioned previously, where the TW group consumed yoghurts and fromage frais more frequently, while the BLW groups ate more cheese. This suggests the form of dairy products (or non-dairy alternatives) is influencing intake. Yoghurts and fromage frais are common weaning foods that lend themselves to spoon-feeding and are unlikely to be offered to BLW infants. However, avoidance of any spoon-feeding on principle by parents who take a strict view of BLW may be impacting on their child's intake of calcium, which may have repercussions if this low intake level continues through childhood. However, this needs to be balanced with the likelihood of taking in substantial amounts of sugar contained in some dairy products marketed towards infants (Crawley and Westland, 2017; Garcia et al., 2020)

5. Is BLW sufficient or significantly different to traditional weaning?

There are clearly aspects of baby-led weaning that are significantly different to traditional weaning. Firstly, one difference seen both in previous research and these studies, is that BLW commences later than traditional weaning. The strict BLW group in each sample, was more likely to introduce solids later than either the loose BLW or TW groups. In the survey detailed in chapter three, the mean age for the introduction of solids was 25 weeks in the strict BLW group and 22.4 weeks in the TW group, while in the three day diet diary, solids were introduced at 25.4 weeks in the strict BLW group, and 24.3 weeks in the TW group. Clearly this is to be expected when using a method of feeding relying on a child being developmentally able to self-feed, but it does highlight that many using traditional spoon-feeding are introducing solids earlier than recommended by the WHO and the UK government.

In line with previous research, mothers using BLW were more likely to breast feed than those using other methods. In study three, 86% of participants using a strict form of BLW were breastfeeding, as opposed to 37% in the TW group. In study four, 88.4% of the BLW group breast fed compared to 60.4% in the TW group. It should be noted however, the breast feeding rates seen throughout this thesis were much higher than current UK rates, estimated at 1% exclusive breastfeeding and 34% maintaining any breastfeeding at 6 months (McAndrew et al., 2012). Respondents to the study were likely highly-motivated and not representative of the wider population, however the fact that BLW seems supportive of breastfeeding should be welcomed.

One important aspect of baby-led weaning which has been highlighted by these studies in particular is the slower transition to solids, as evidenced by the lower energy intake in younger infants taking part in the weighed three day food record and the wider use of low energy density fruit and vegetables in studies two and three. The lower caloric intake at the start of weaning probably resulted from a dietary pattern including more vegetables, citrus fruits and protein foods among strictly BLW infants, a higher intake of convenience foods in the loose BLW group and increased use of commercial infant foods such as baby rice among the TW group, which tend to be more energy dense than fruit and vegetables. As discussed previously, pureed infant meals such as those found in pouches and jars can be high in starches and sugars, and contain portion sizes which can be in excess of what is needed by infants of this age (Crawley and Westland, 2017). This slower transition in complementary feeding could be beneficial for a child's weight trajectory and their relationship with food, if adequate, energy and nutrient dense foods are supplied by a parent, but given there was no significant difference in the weight of weaning groups and no instances of IDA in this study, this would suggest their intake alongside milk, is sufficient to support healthy growth and development, which challenges some of the concerns raised in study one.

In terms of behavioural differences, baby-led weaning infants were reported to be less fussy and enjoy a wider variety of food, particularly at start of weaning, as shown by the Children's Eating Behaviour Questionnaire, FFQ and survey of enjoyment in study two. In addition, this survey showed them to be more satiety responsive than traditionally weaned infants throughout the first six months of the weaning process. These differences have been seen in prior work and seem to be characteristic of a behavioural pattern in infants and toddlers weaned in a baby-led manner. Further research is needed to observe whether these patterns extend into later childhood and to clarify any associations between these behaviours and weight trajectories as healthier weight is often promoted as a benefit of BLW by its proponents but the evidence is as yet mixed.

Finally, the results of this thesis showed differences in specific nutrient intakes between weaning groups, with the BLW infants having a lower intake of energy and many nutrients during the early part of the weaning process. Calcium intake was lower among BLW infants in study four, possibly due to lack of spoon-feeding dairy products as seen in studies two and three, while carbohydrate and sugar intake was higher among those in the TW group. Interestingly, neither group met the RNI for iron, intake of which was closely related to the type of milk feeding used. These findings suggest further research is needed to clarify the iron status of infants breastfed using BLW, as discussed in the following section.

Aside from these findings, what are the long term effects of starting life weaned differently? Clearly, this depends on the characteristics and experiences of the weaning method used and the interplay between these and the genetic background of the child. As discussed previously, weaning method could impact long term food preferences: exposing a child to a wide variety of foods in the weaning period may result in a preference for a range of nutrient-dense foods as they go through childhood, which has long term health repercussions due to the enduring nature of preferences (Nicklaus et al., 2004; Switkowski, Gingras, Rifas-Shiman, & Oken, 2020). Contrast this to the bland, vaguely sweet taste of many commercial purees (Crawley and Westland, 2017), which does not expose the child to strong flavours that they can become accustomed to over time. This may limit a child's intake of nutrients and phytochemicals, which has long-term health implications (Setayeshgar et al., 2017).

In addition, if children have a genetic predisposition to being hungrier or less satiety responsive due to specific SNPs (Loos and Yeo, 2014), the immediate gratification of spoon-feeding and the potential reduced sensitivity to internal hunger/satiety cues, might nudge child into a slightly higher weight trajectory which, if continued might lead to obesity and its comorbidities later in life.

Clinical Relevance

These studies have demonstrated that although there were key differences in the characteristics of infants using BLW and their intake and eating behaviours, there were many similarities between the groups in terms of dietary intake, particularly when infants moved towards the latter part of weaning. Overall BLW appears to be a safe and sufficient way to introduce solids to infants, although any messaging around promoting the method needs to focus on certain aspects of the context of feeding and types of food offered.

Perhaps the most pertinent contrasts between a baby-led and traditional approach, are a more gradual transition to solids and greater perceived satiety responsiveness in those infants who self-fed. The gradual transition to solids seen in infants following a strict form of BLW can be beneficial to weight trajectories, ensuring weight gain is not rapid, which has been shown to have negative impact on BMI over time (Lu, Pearce, & Li, 2020; Zheng et al., 2018). However, it is important that this transition is not too slow and that infants are offered a range of nutrient and energy dense foods given their period of rapid growth and development. Lessons can be learnt from the BLISS project, where those advising parents using BLW should encourage them to offer energy and nutrient-dense foods such as meat, fish and poultry, lentil patties and omelette strips as well as avocado pieces and full-fat cheese, and some of these recommendations could be incorporated into any educational materials produced for professionals or parents using BLW in the future

To address some of the concerns highlighted, such as low calcium intake in BLW infants, professionals could emphasise offering pieces of cheese or calcium fortified foods and drinks if parents are using plant-based diets, which are growing in popularity. Additionally parents who are using BLW could spoon feed their baby a few spoons of yoghurt. There is a tendency towards rigid thinking for some parents using BLW, who believe giving any spoons or helping feed their child at all will negate any benefits to this approach. Previous research on BLW has used a definition of using a spoon <10% of the time to indicate parents are compliant (Brown and Lee, 2011c; Brown and Lee, 2015), and increasing an infant's intake of micronutrients such as calcium would be relatively easy: a small pot of calcium enriched fromage frais contains about 70mg calcium, enough to reduce the difference between the intake of the strict BLW group and the TW group. Two small pots would be enough for the intake in the BLW group to attain the RNI.

In addition, an implication of the 24 hour recall and FFQ results is that some of those using a less strict form of BLW, which may in fact be very similar to traditional weaning, are offering foods which may not be the best options for infants during this vital period when infants are forming their long-term taste preferences. The higher levels of processed and convenience foods offered by parents identified as using "loose" BLW, are highly palatable and therefore may be chosen by children in preference to less tasty but more nutritious foods. Foods should not be demonised but reliance on convenient but highly processed foods in early weaning should be avoided if possible. However, it is understandable that many parents have little time or energy to prepare meals from scratch, particularly if they have other children. Indeed, parents in the loose BLW group were more likely to be multiparous, one reason perhaps, why they may have been more likely to use convenience foods like savoury snacks, chips and pizza.

Related to convenience, BLW is often stated to be cheaper than traditional weaning because infants are offered family foods (Rapley, 2011; Rowan and Harris, 2012), rather than commercial infant foods, which were used more in the traditional and loose BLW groups in these studies. However, recent data from the BLISS study have shown although the cost of food was perceived as lower by BLW parents, the actual cost was just 20-30 New Zealand cents (10-20p) a day cheaper (Bacchus et al., 2020). The BLISS study did not consider the intakes of infants using a ”loose” version of BLW, who may be relying on commercial finger foods like crackers and crisps. For these parents, BLW might be more expensive and it would be interesting to price the diets of our participants to ascertain whether the cost of BLW depends on the way it is implemented. In addition, the use of family foods as weaning foods depends on whether families can ensure the foods are suitable. Families living in poverty may not have the facilities or skills to prepare low-sodium food for example, so a blanket recommendation for using family foods in weaning would be unrealistic and harmful. Parents need to be supported to make healthy choices for their families and helped to improve their food literacy focusing on how to provide cheap, tasty, nutrient-dense foods, following the suggestion recommended by the First Steps Nutrition Trust (Crawley, 2015).

This brings us to another finding of this study, which was the increased level of carbohydrate and sugars in the TW group seen in the diet diary. As previously mentioned, this could be due to their use of commercial purees in jars and pouches, which contain sugars that should be labelled as free sugars. This has implications for dental health and due to their impact on flavour preference, may have long-term consequences such as higher weight trajectories. Although in this study, the parent-reported weight of infants was not significantly different between weaning groups, it is possible the higher energy intake seen in the TW group may lead to abnormal weight gain if consistently repeated over time, especially if viewed in combination with the differences in eating behaviour that parents observed in TW and BLW infants. Clearly, free sugars should be recorded on infant food labels as a matter of urgency and parents should be informed about the use of fruit-based purees in the food industry and its potential harms, as highlighted by the WHO in its 2019 report: Commercial Foods for Infants and Young Children in the WHO European Region (WHO, 2019).

Finally, the diet diaries were a reminder that parents of breast fed babies and those no longer receiving at least 500ml of formula daily should supplement their babies with vitamin D. This study did not take supplements into account, and as expected, the dietary intakes of vitamin D were extremely low for all groups, which emphasises the need for supplementation in this population.

Given the growing popularity of baby-led weaning and that parents may turn to Health Visitors for advice during the early months with a new baby, it would seem prudent to equip health care professionals with evidence-based materials and training to ensure they feel confident in the advice they give. One of the calls from professionals in study one was for training and guidance from government departments on whether BLW is safe and sufficient. As it stands, there is still no official stance on this issue, which means parents may not be receiving evidence-based advice, and research has shown parents using BLW look to online groups and websites for advice rather than professionals (D'Andrea et al., 2016), resulting in potentially unsafe advice being taken.

Given the latest SACN report on feeding infants in the first year of life highlights the growth of BLW, and the growing body of evidence, it feels pertinent to move towards clearer health professionals receiving evidence based training rather than some feeling underprepared to support parents questions. As outlined in chapter two, creating an online training seminar, which could either be virtually attended by Health Visitors as part of CPD or recorded and saved as a YouTube resource for example, would be a cost-effective and simple strategy for educating professionals on both the evidence-base behind BLW and how it can safely be implemented by parents. Professionals could also be supplied with booklets or other simple materials such as a laminated sheet to put on a fridge, which parents could refer to for tips and advice on how to use BLW or more broadly, how to offer lots of different finger foods safely and effectively, whether it is labelled as BLW or not.

In conclusion, it should be noted that in spite of the differences in intake and eating behaviour between weaning groups, there were many similarities. This may have been due to the demographic similarity of the groups, which was probably related to the motivated, self-selecting nature of the sample, which as discussed below limits the generalisability of the results. There are also many parents for whom BLW does not appeal, and many infants where it would not be practical developmentally. Professionals need to be as aware of these limitations, as they are regarding the similarities between methods and should endeavour to support parents spoon-feeding to adopt some of the practices associated with BLW such as sitting together for family meals, responsive feeding and the chance to explore finger foods from the start of weaning.

Limitations of the thesis

Although this set of studies is unique in culminating in a weighed three day diet diary of infants being introduced to solids using baby-led weaning in the United Kingdom, there are limitations to some aspects of the research that are important to consider especially if reflecting on what information and support parents should receive around the BLW approach.

Firstly, although validated research tools were used, all the data were generated by parents rather than being collected by an independent researcher. This risked introducing bias and errors into the data as parents may have been concerned with presenting their child's diet as "healthy" or an excellent example of baby-led weaning in practice. Alternatively they may have been rushed or stressed and made mistakes in weighing food, recording intake or may have forgotten what was eaten: underreporting is widespread in dietary intake assessments (Dao et al., 2019). However, these methods of measuring dietary intake are widely used and limitations in the various methods were compensated for by using three different designs to capture varying aspects of intake. This strategy was validated by the fact that similar patterns of eating and food choices were seen in the various intake surveys.

Additionally, the number of respondents to the weighed diet diary was low due to difficulties with recruitment. Recruitment to this study was challenging because of the burdensome nature of the diet diary, as all food and leftovers had to be weighed and noted for three days, including time spent breast feeding. When those who had initially showed interest in taking part in the study were made aware of its details, many declined to take part or simply did not respond to the researcher. This may mean that those who decided to take part were highly motivated or particularly interested in the topic of infant feeding and may differ in their overall approach in caring for their baby. On the other hand, those who declined to take part may not have lacked motivation, rather they may have had other children to care for, time constraints due to work or caring duties, or they may have felt their child was a difficult or fussy eater which would make the study too stressful. The lack of financial compensation on offer may have put some participants off or perhaps there was a lack of interest in something seen as "alternative".

Moving to the study design, being cross-sectional, the studies provided a snap shot of infant intakes in separate groups, rather than being longitudinal, which would have tracked changes within each infant's diet over time. This would have provided useful data as infants diets change as they grow, demonstrated by markedly different intakes between the various age groups. It would have been interesting to see whether the dietary patterns and behaviours observed in strictly BLW infants such as higher vegetable intake and lower fussiness continued into toddlerhood and beyond, particularly given the paucity of research in this area in the UK. However, this was not feasible within the confines of this PhD candidature. At the time of starting the research there was no published research on the intake of BLW infants and therefore it was prudent to start with cross sectional studies to identify any initial differences.

In common with other studies exploring a baby-led approach, the results of these studies may not be generalisable to a wider population because of the highly motivated nature of the study respondents, particularly those taking part in the three day diet diary. As mentioned previously, mothers who use BLW are more likely to be well-educated, in a professional occupation and breast feed their babies more than those using a traditional approach (Brown and Lee, 2011a), yet it should be noted participants in the TW groups throughout these studies had a higher education level than the UK average and had higher breast feeding rates than would be expected, suggesting the whole sample was unrepresentative. Recruitment in baby groups with a wider demographic composition local to the researcher was unsuccessful, possibly because of the effort required from parents as outlined on the previous page. In practice, in spite of its growing popularity, baby-led weaning may not appeal to a wide variety of parents and as demonstrated by these studies, given that implementing the method safely requires thought and planning (providing nutrient dense, iron rich low salt foods, with a low choking risk), it may not be suitable for parents without an adequate understanding of basic nutrition and food preparation skills.

Another point to note regarding parents using BLW, is that some of the positive perceptions reported in these studies could be wishful thinking on the part of those who may be emotionally invested in the method being successful. Locke (2015) suggests baby-led weaning is a facet of "intensive mothering" and engenders feelings of superiority in those who identify with its ideals (Hays, 1998). BLW is seen as part of a parenting "project" and has been described as one aspect of being a perfect mother, alongside breastfeeding on demand, co-sleeping and cloth nappies (Locke, 2015). Clearly, if a parent has taken on this identity, their perceptions about whether baby-led weaning is "working" for their child may be influenced by the desire for their project to succeed. Although this perspective is worth bearing in mind, it is speculative without further research into the motives and lifestyles of those using BLW. Although research on mothers' experiences to date has highlighted its use among mothers who are older and more educated, findings have been generally positive and have emphasised the practical benefits of baby-led weaning for families (Brown and Lee, 2011a, 2013; Cameron et al., 2012a; D'Andrea et al., 2016)

In spite of its limitations, given the small evidence base for baby-led weaning, this thesis provides novel findings on how it is viewed by professionals and the nature of its use and the intakes of infants weaned in the manner in the UK. By bridging the gap between the perceptions held about BLW and how it is working, this work seeks to give professionals working in this area an increased knowledge base from which they can support parents in their choices.

Future research

As discussed in the section above, one of the limitations of this series of studies was the inability to track changes in eating behaviour and intake longitudinally, however, future research could address this shortcoming. There is in fact scope for developing a second investigation with some of the participants in the three-day diet diary study as many gave permission to be contacted in the future. As the diet diary study was carried out over a period of years, participating infants would now be either approaching school age or navigating the prime age for food neophobia. It would be interesting to see whether the satiety responsiveness and reduced fussiness reported by parents of infants in this study compared with traditionally weaned children is seen in toddler and pre-schoolers who followed a baby-led approach, and an intake survey would highlight whether the eating patterns reported in infancy are persistent. As yet there is no available data looking at the eating behaviours, weight and intake of school-age children who were weaned using a baby-led approach.

This is important due to the potentially profound long term effects that could result from the eating behaviours and dietary patterns associated with BLW. For example, healthy weight trajectories lasting into childhood and beyond due to greater sensitivity to internal hunger and satiety cues and consumption of a wider variety of healthy foods. The differences seen between weaning groups may be impactful both for individual children and wider society if indeed differences persist into the years when children are exposed fully to the obesogenic environment. It would be interesting to note whether early patterns of eating associated with BLW, such as food variety and acceptance, can withstand the pressures of our current food environment. This underlines the need for research on older children who have been weaned using BLW, given this method has been used and documented for over ten years.

In addition, to improve the generalisability of any further research around BLW, particularly those using weighed diet diaries, efforts should be made to recruit a larger, more inclusive sample. This could potentially be achieved by working with different agencies and gaining support from local health visitors and GPs, as health professionals have access to parents from a variety of economic and ethnic backgrounds. It would be interesting to explore whether BLW is indeed as Locke (2015) suggests, a facet of competitive mothering, part of a parenting "project" used by privileged women to differentiate themselves and feel superior, or whether it is used by women of more diverse backgrounds and if so, is it used in the same way. Working with health care providers on any future research would also facilitate collection of health outcomes such as serum iron and zinc levels or prevalence of iron deficiency anaemia in the sample.

Another opportunity for further research may arise if regulations around the labelling of infant foods changes to reclassify fruit purees as free sugars. Research to highlight the potential differences in free sugar intake between weaning styles, may highlight a concrete and actionable contrast. Likewise, UK-specific work on the cost to families of different weaning approaches would provide evidence to support some of the claims of those promoting BLW, particularly if those following a "loose" form use pouches and commercial snack foods more than those using a strict form of the method.

Finally, given the desire for more training and guidance from those working in the sector, further research should identify which professions and what training materials could be produced to aid those advising parents on the safety and efficacy of baby-led weaning.

Conclusion

The aim of this thesis was to explore the dietary intake of infants using the baby-led weaning approach to the introduction of complementary foods, compared to those following traditional spoon-feeding practices. It started by identifying health professionals concerns regarding energy and nutrient intake amongst infants following a baby-led approach and used those concerns to develop three exploratory, interlinked studies examining infant eating behaviour, food exposure, and energy and nutrient intake amongst infants aged 6 – 12 months following different weaning approaches.

The results presented a mixed picture. Although for many foods and nutrients there was little difference in preference, exposure or consumption, some key differences between the groups emerged. Notably, significantly more differences were identified amongst younger infants aged 6 – 8 months with these differences often not present in infants aged 9 – 12 months suggesting methods align as infants move through the weaning period. On the one hand this is a positive effect; infants following a BLW approach had a more gradual introduction to solid foods, in line with WHO recommendations, including earlier and wider exposure to a range of vegetables and protein rich foods in their 'whole form'. BLW infants also consumed fewer commercial products or those higher in sugar.

However, for some this introduction may have been too slow, relying too much on milk and avoiding some nutrient rich foods that may not be easy to self-feed such as yoghurt. Notably, when parents followed BLW in a 'loose' form they were more likely to offer foods that infants can easily self-feed but may not contribute positively to an infant diet in large amounts such as bread sticks and crackers. Many infants in the study regardless of weaning approach were also consuming much lower levels of important micronutrients such as iron, which may be exacerbated in BLW infants by lower consumption of spoon-able infant foods that have been fortified with vitamins and minerals. It is clear that any guidance to support parents in following a BLW approach needs to focus on ensuring guidelines around energy and nutrient intake are followed rather than relying too simplistically on the idea of 'simply feed your infant family foods'.

Appendices

Attitudes and experiences of healthcare professionals on Baby-led Weaning

This questionnaire is part of a research study looking at the views and experiences of healthcare professionals on Baby-led Weaning (BLW), which is part of a wider study investigating the differences (if any) between babies weaned using traditional methods (e.g. spoon-fed purees) and BLW. Before you decide whether or not to participate, it is important for you to understand why the research is being conducted and what it will involve. Please read the following information carefully.

The survey will ask you some general questions about your understanding of BLW as it relates to your professional practice and your opinions on this method of introducing solids. The aim of the questionnaire is to examine the pros and cons of BLW from the point of view of those professionals who work with parents using this method with their children. Overall, this survey should take 10-15 minutes to complete.

The data are being collected by Hannah Rowan at the Department of Health Sciences, Swansea University, under the supervision of Dr Amy Brown, Department of Health Sciences, Swansea University. The research has been approved by the Department of Psychology's Research Ethics Committee.

If there are any questions you do not wish to answer for any reason please leave them blank. In addition, if you do not wish to complete the questionnaire for any reason please do not continue. If you wish to withdraw from the study you can do so simply by closing your browser.

There are no right or wrong answers - we are interested in your experiences and opinions so please answer as fully as possible. Any information that you do give in the questionnaire will only be used for the purposes of the study, and will be kept confidential. You will not be identified from your answers in any way. When you press the submit button at the end, your information will be anonymously added to the study and you will be identified via a participation number, not by name. Please note that because the data will be made anonymous, it will not be possible to identify and remove your data at a later date, should you decide to withdraw from the study.

An analysis of the information will form part of our report at the end of the study and may be presented to interested parties and published in scientific journals and related media. Note that information presented in any reports or publications will be anonymous.

If you have any questions please do not hesitate to get in contact with Hannah Rowan or Dr Amy Brown in one of the following ways:

Hannah Rowan email: [redacted]

Dr Amy Brown email: [redacted]
Phone: [redacted]

Consent for participation in this survey of attitudes to Baby-led weaning among healthcare professionals

By clicking "next" and continuing on to the questionnaire, I am consenting to take part in the study and:

I agree to take part in the above research. I have read the Participant Information Sheet above. I understand what my role will be in this research, and all my questions have been answered to my satisfaction.

I understand that participation is voluntary and also that I am free to withdraw from the research at any time, for any reason and without prejudice.

I have been informed that the confidentiality of the information I provide will be safeguarded.

I have been provided with a copy of the Participant Information Sheet.

I understand that it will not be possible to identify my data at a later date.

I am aged 18 years or above.

Data Protection: I agree to the University processing personal data that I have supplied. I agree to the processing of such data for any purposes connected with the Research Project as outlined to me.

Participant Information

1. What is your profession or job title?

- ○ GP
- ○ Dr. – other than GP, please state below
- ○ Health Visitor
- ○ Registered Dietician
- ○ Nutritionist
- ○ Nurse
- ○ Other – please state below

Other (please specify)

2. What is the first half of the postcode where your practice is based

3. How many years have you been in practice?

Baby led weaning (BLW) is defined as a baby being offered finger food or food in its whole form (not pureed or mashed) and the baby self-feeding rather than being fed by a parent or caregiver. This is in contrast to traditional weaning, which is the spoon-feeding of purees and baby cereal to babies by parents.

4. Have you heard of the term Baby Led Weaning (BLW) in terms of introducing solid foods to babies?

- Yes
- No
- Not sure

5. If you know about BLW, when and where did you first come across the term?

- Client or patient query
- Professional training
- Internet browsing
- Book or magazine
- Professional or academic journal article

Other (please specify)

6. Have you experienced BLW in your professional capacity or had patients who were using BLW with their child?

- Yes
- No
- Not sure

7. If yes, how did you feel about it?

8. What advice are you able to offer if a parent asks for guidance on using BLW with their baby?

9. What has been your professional experience of seeing how BLW has worked (or otherwise) with parents and their children?

10. Have you had any professional training on BLW?

- Yes
- No
- Not sure

11. Do you feel confident in your knowledge about BLW?

- Yes
- No
- Not sure

12. What do you see as the advantages of a Baby Led approach to solid food introduction?

13. What do you see as the disadvantages of a Baby Led approach to solid food introduction?

14. Do you have any concerns about the Baby Led approach?

15. What is your opinion of the effects of a using BLW on a child's nutrient and energy intake?

16. Would you like more information and training on BLW and how it can be implemented?

- Yes
- No
- Not sure

17. Do you have any other comments?

This is the end of the questionnaire. Thank you very much for taking the time to complete it.

If you have any questions or if any concerns have been raised by your participation in this research, please get in contact with the study coordinators as listed below.

Please remember, all responses will be treated confidentially.

Hannah Rowan email: [redacted]

Dr Amy Brown email: [redacted]
Phone: [redacted]

Background: An exploration of nutrient intake in baby-led versus traditiona...

We are conducting research on the differences (if any) between babies weaned using purees and those introduced to solids using Baby-led weaning. The survey will look at your baby's diet and your experience of introducing solid foods to your child.

The aim of the questionnaire is to get a better understanding of the diet of babies during the weaning process and to explore how different styles of weaning may impact on energy and nutrient intake.

We will ask you some general background questions about yourself and your baby before moving onto how you are introducing solid foods, the way you feed your baby and your baby's diet. Most of the questions are multiple choice but there are some sections where you will have to fill in some details of what your baby has been eating.

Overall, the survey may take 30-45 minutes to complete.

If there are any questions you do not wish to answer for any reason please leave them blank. In addition, if you do not wish to complete the questionnaire for any reason please do not continue. If you wish to withdraw from the study you can do so simply by closing your browser. Importantly, if answering any of the questions raises concerns about yourself or your child in any way, you should contact your health visitor or GP for further advice or support.

There are no right or wrong answers - we are interested in your experiences and the foods your baby is eating so please answer as fully as possible. Any information that you do give in the questionnaire will only be used for the purposes of the study, and will be kept confidential. You will not be identified from your answers in any way. When you press the submit button at the end, your information will be anonymously added to the study.

The data for this survey are being collected by Hannah Rowan at the Department of Health Science, Swansea University, under the supervision of Dr. Amy Brown, Department of Health Science, Swansea University. The research has been approved by the Department of Psychology"s Research Ethics Committee.

All the data obtained will be confidential to the study. You will be identified via a participation number, not by name.

Please note that because the data will be made anonymous, it will not be possible to identify and remove your data at a later date, should you decide to withdraw from the study. Therefore, if at the end of this research you decide to have your data withdrawn, please let us know before you leave.

An analysis of the information will form part of our report at the end of the study and may be presented to interested parties and published in scientific journals and related media. Note that information presented in any reports or publications will be anonymous.

If you have any questions please do not hesitate to get in contact with Hannah Rowan or Dr Amy Brown in one of the following ways:

Hannah Rowan email: [redacted]

Dr Amy Brown email: [redacted]
Phone: [redacted]

Exploring nutrient and energy intake in infants weaned using a baby-led or traditional feeding style.

Consent:
By clicking "next" and continuing on to the questionnaire, I am consenting to take part in the study and:

I agree to take part in the above research. I have read the Background Information above and I understand what my role will be in this research, and all my questions have been answered to my satisfaction.

I understand that participation is voluntary and also that I am free to withdraw from the research at any time, for any reason and without prejudice.

I have been informed that the confidentiality of the information I provide will be safeguarded.

I am free to ask any questions at any time before and during the survey.

I understand that it will not be possible to identify my data at a later date, and therefore if I wish to withdraw my data from the study, I will need to do so before finishing and submitting the survey.

I am aged 18 years or above.

Data Protection: I agree to the University processing personal data that I have supplied. I agree to the processing of such data for any purposes connected with the Research Project as outlined to me.

All about you

1. How old are you?

2. What is your highest level of education?

- No formal qualifications
- GCSE level or equivalent
- A level or equivalent
- Degree level or equivalent
- Postgraduate or equivalent

3. Are you currently working?

- Full time
- Part time
- Maternity leave (will return)
- Maternity leave (will not return)
- Not working

4. What is your occupation?

5. What is your household income?

- Up to 15000
- 15001-25000
- 25001-40000
- 40001-75000
- More than 75000
- Rather not say

6. What is your ethnic group? Please choose the option that best describes your ethnic group or background

- ○ White (British, Irish)
- ○ Gypsy or Irish Traveller
- ○ Mixed ethnicity
- ○ Asian
- ○ Chinese
- ○ Black / African / Caribbean / Black British
- ○ Arab

Other (please specify)

[ ]

7. Which of the following best describes your current relationship status?

- ○ Married
- ○ Widowed
- ○ Divorced
- ○ Separated
- ○ In a domestic partnership or civil union
- ○ Single

8. What is your current weight?

[ ]

9. What is your height?

[ ]

All about your baby

10. Is this your first baby?

- ○ Yes
- ○ No

11. If this is not your first baby, how many other children do you have?

- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5
- ○ 6

Other (please specify)

Please answer all further questions considering your current baby aged 6 - 12 months rather than any older child

12. What is your child's gender?

- ○ Female
- ○ Male

13. What is your baby's age in weeks?

14. What was the birth weight of your baby?

15. What is your baby's current weight? If you are not sure please leave this section blank.

16. Is your baby in daycare/nursery or with a childminder?

- ○ Yes
- ○ No

17. If yes, how many days per week in total is your baby in daycare/nursery or with a childminder?

- ○ Less than 1 day
- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5
- ○ 6
- ○ 7

18. How was your baby fed at birth?

- ○ Breast
- ○ Expressed breast milk
- ○ Formula

19. If you have finished breast feeding, how old was your baby when you stopped?

[ ]

20. If you breastfed at birth but introduced formula alongside breastmilk , how old was your baby when you first started using it?

[ ]

Introducing solid foods

The following questions are concerned with solid foods. In this study, Baby led weaning (BLW) is defined as a baby being offered food as finger food or in its whole form (not pureed or mashed) and the baby self-feeding rather than being fed by a parent or caregiver. Traditional weaning is defined as the spoon-feeding of purees and baby cereal to babies by parents.

Please note that by "eating" we are referring to any food (other than breast milk or formula) that's swallowed in any amount.

21. How old was your baby (in weeks) when you first introduced solid foods?

22. What were your main reasons for introducing solids at this time? Please check all that apply?

- ☐ Signs of readiness (e.g. baby sitting up, bringing food to mouth)
- ☐ Hunger
- ☐ Not enough milk
- ☐ Needed new tastes
- ☐ Needed more nutrients
- ☐ Lost weight/low weight
- ☐ Big baby/too big
- ☐ Certain weight reached
- ☐ Encourage sleep
- ☐ Make more settled
- ☐ Interest in food
- ☐ Grabbed food/self-fed
- ☐ Cried when saw food
- ☐ Teeth
- ☐ Physically advanced
- ☐ Putting things in mouth
- ☐ Pressure from others
- ☐ Health professional advised
- ☐ Medical reasons
- ☐ Return to work
- ☐ Less hassle
- ☐ Routine
- ☐ Fun
- ☐ Bored of milk
- ☐ Excitement

Other (please specify)

23. What was the first food you gave your baby?

24. Was the first food you gave them home made or commercially prepared? E.g. carrots cooked at home, jarred food or baby rice?

- Home-made
- Commercial

25. Was the first food pureed or in its whole form? E.g. a carrot stick or apple sauce?

- Whole form
- Pureed

26. If you have started giving your baby finger food, at what age did you first do this? Examples of finger foods include toast, banana (not mashed) or a carrot stick.

27. How often during the day were they having solid foods at 6 months?

28. Baby led weaning is the process of placing foods in front of your baby and letting them feed themselves - picking the food up themselves and putting it in their mouths unassisted, rather than being spoon-fed by a parent. This could involve them using a spoon themselves. Baby-led weaning tends to involve offering the baby family foods rather than offering pureed foods.

Have you heard of baby led weaning?

- Never heard of it
- Heard of it but don't know anything about it
- Know a little about it
- Know a moderate amount about it
- Know a lot about it

29. Looking at the description above, would you say that you are following Baby led weaning?

- Yes - strictly
- Yes - loosely
- No
- Don't know

30. If your baby is in your care, how would you describe the method of feeding?

- Spoon fed by adult
- Predominantly spoon fed, very occasionally baby led feeding
- Mostly spoon fed by adult, some baby led feeding
- About half spoon feeding by adult and half baby led feeding
- Mostly baby led feeding, some adult spoon feeding
- Predominantly baby led, very occasionally adult spoon feeding
- Baby led feeding

31. If your baby is in your care, how would you describe the type of food they eat? Finger foods refer to non-pureed foods in their whole form e.g. piece of toast, pasta shape, cooked broccoli spear

- Pureed food or baby rice etc
- Predominantly pureed food, very occasional finger foods
- Mostly pureed food, some finger foods
- About half purees and half finger foods
- Mostly finger foods and some purees
- Predominantly finger foods, very occasional pureed food
- Finger foods

32. Of the food you give your baby, what proportion do you think they actually eat as opposed to being played with, spat out or thrown on the floor?

- All (or nearly all) of it
- Most of it
- About half of it
- A little of it
- Hardly any of it or none at all

33. If applicable, how would you describe the method of feeding if your baby is in someone else's care e.g. nursery?

- Spoon fed by adult
- Predominantly spoon fed, very occasionally baby led feeding
- Mostly spoon fed by adult, some baby led feeding
- About half spoon feeding by adult and half baby led feeding
- Mostly baby led feeding, some adult spoon feeding
- Predominantly baby led, very occasionally adult spoon feeding
- Baby led feeding
- Not applicable

34. If applicable, how would you describe the type of food they eat if your baby is in someone else's care e.g. nursery?

- Pureed food or baby rice etc
- Mostly pureed food, some finger foods
- About half purees and half finger foods
- Mostly finger foods and some purees
- Finger foods
- Not applicable

35. If your family sit down at the table and eat a meal does your baby sit with you too?

- Never
- Occasionally
- About half the time
- Most of the time
- All the time

36. If your baby eats with you, do they eat foods from the meal you are eating even if modified e.g. no salt?

- Never
- Occasionally
- About half the time
- Most of the time
- All the time

37. If they join in the family meal time how do they eat these foods?

- Spoon fed by adult
- Predominantly spoon fed, very occasionally baby led feeding
- Mostly spoon fed by adult, some baby led feeding
- About half spoon feeding by adult and half baby led feeding
- Mostly baby led feeding, some adult spoon feeding
- Predominantly baby led, very occasionally adult spoon feeding
- Baby led feeding
- Not applicable

38. What consistency is the food when you give it them?

- Pureed food
- Mashed food
- Chopped food
- Whole food - same as family

39. Are you happy with your choice of weaning style whether that is baby led or parent led?

- Very unhappy
- Unhappy
- Neither happy nor unhappy
- Happy
- Very happy

40. In an ideal world would you be:

- Much more baby led
- Slightly more baby led
- Stay the same
- Slightly more parent led
- Much more parent led

41. I feel confident about giving my baby solids

- Disagree
- Slightly disagree
- Neither agree nor disagree
- Slightly agree
- Agree

42. I worry about my baby choking when she is eating solids

- Disagree
- Slightly disagree
- Neither agree nor disagree
- Slightly agree
- Agree

43. I worry my baby isn't eating enough solid food

- Disagree
- Slightly disagree
- Neither agree nor disagree
- Slightly agree
- Agree

44. I worry my baby isn't getting enough nutrients from the solids they eat

- Disagree
- Slightly disagree
- Neither agree nor disagree
- Slightly agree
- Agree

45. I feel very knowledgeable about introducing solids to my baby

- Disagree
- Slightly disagree
- Neither agree nor disagree
- Slightly agree
- Agree

46. My baby accepted solids very easily and quickly

- Disagree
- Slightly disagree
- Neither agree nor disagree
- Slightly agree
- Agree

47. Feeding my baby solids is a stressful experience

- Disagree
- Slightly disagree
- Neither agree nor disagree
- Slightly agree
- Agree

Feeding your baby

48. Please read the following statements and tick the boxes most appropriate to your child's eating behaviour.

	Never	Rarely	Sometimes	Often	Always
My child loves food	○	○	○	○	○
My child has a big appetite	○	○	○	○	○
My child finishes his/her meal quickly	○	○	○	○	○
My child is interested in food	○	○	○	○	○
My child refuses new foods at first	○	○	○	○	○
My child eats slowly	○	○	○	○	○
My child enjoys tasting new foods	○	○	○	○	○
My child is always asking for food	○	○	○	○	○
If allowed to, my child would eat too much	○	○	○	○	○
My child enjoys a wide variety of foods	○	○	○	○	○
My child leaves food on his/her plate at the end of a meal	○	○	○	○	○
My child takes more than 30 minutes to finish a meal	○	○	○	○	○
Given the choice, my child would eat most of the time	○	○	○	○	○
My child looks forward to mealtimes	○	○	○	○	○
My child gets full before his/her meal is finished	○	○	○	○	○
My child enjoys eating	○	○	○	○	○
My child is difficult to please with meals	○	○	○	○	○
My child gets full up easily	○	○	○	○	○
Even if my child is full up s/he finds room to eat his/her favourite food	○	○	○	○	○
My child cannot eat a meal if s/he has had a snack just before	○	○	○	○	○
My child is interested in tasting food s/he hasn't tasted before	○	○	○	○	○
My child decides that s/he doesn't like a food, even without tasting it	○	○	○	○	○

If given the chance, my child would always have food in his/her mouth	○	○	○	○	○
My child eats more and more slowly during the course of a meal	○	○	○	○	○

49. Please read the following statements and tick the most appropriate boxes

	Never	Seldom	Half of the time	Most of the time	Always
When your child is at home, how often are you responsible for feeding her?	○	○	○	○	○
How often are you responsible for deciding what your child's portion sizes are?	○	○	○	○	○
How often are you responsible for deciding if your child has eaten the right kinds of food?	○	○	○	○	○
How much do you keep track of the sweet foods your child eats?	○	○	○	○	○
How much do you keep track of the snack food your child eats?	○	○	○	○	○
How much do you keep track of the high fat food your child eats?	○	○	○	○	○
How concerned are you about your child eating too much when you are not around her?	○	○	○	○	○
How concerned are you about your child being overweight?	○	○	○	○	○
How concerned are you about your child maintaining a desirable weight?	○	○	○	○	○
How concerned are you about your child becoming underweight?	○	○	○	○	○

50. Please read the following statements and tick the most appropriate boxes

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Agree strongly
I have to be sure that my child does not eat too many sweet foods	○	○	○	○	○
I have to be sure that my child does not eat many high fat foods	○	○	○	○	○
I have to be sure that my child does not eat too much of her favourite foods	○	○	○	○	○
If I did not guide or regulate my child's eating, she would eat too much	○	○	○	○	○
My child should always eat all the food given to her	○	○	○	○	○
I have to be especially careful to make sure my child eats enough	○	○	○	○	○
If my child is not hungry, I try to get her to eat anyway	○	○	○	○	○
If I did not guide or regulate my child's eating, she would eat less than she should	○	○	○	○	○
I try to keep a certain amount of time between my baby's meals or milk feeds	○	○	○	○	○
I follow a feeding routine for my baby	○	○	○	○	○
I check the time to see if my baby needs a meal or feed	○	○	○	○	○
If my baby does not seem hungry at a particular time I try to get her to eat or feed anyway	○	○	○	○	○

My baby's diet

To get the best picture of your baby's diet, please answer as fully as you can

51. What your child eats - 24 hour recall
What did your child eat yesterday (or the last day your baby was in your care)? Please note everything that your child ate and drank, including quantities of formula and cow's milk. If breast feeding, please note how long your baby nursed for at each session.

For example:

7am Follow-on formula 200ml

9am Whole wheat toast with butter 1 slice

11am Follow-on formula 200ml

1pm 1 jar chicken and veg baby food 50ml

3pm 8" banana Half

6pm Pureed carrots 50ml

7pm Follow on formula 200ml

52. Yesterday my baby ate:

- Much more than usual
- More than usual
- The same as usual
- Less than usual
- Much less than usual

53. The types of food my baby ate yesterday were similar to what they usually eat

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

54. Does your baby get any vitamin drops? If so, which brand?

55. Please note approximately how many times each liquid was drunk in the previous 7 days.

Breast milk

Baby formula

Cows' milk and other non-baby milks

Fruit juice (including baby juices)

Fruit squashes (including diet squash)

Tea/coffee

Fizzy drinks (including diet drinks)

Other drinks

Water

56. Please note approximately how many times each food was eaten (in any amount) in the previous 7 days in its whole form or as finger food, if you have started giving your baby finger foods. If not, please leave blank.

Baby dried cereals	
Baby biscuits/cookies	
Baby crisps/crackers	
Baby dried desserts	
Baby dried savoury meals	
Rusks	
Cheese	
Yoghurt and fromage frais	
Processed meat products e.g. sausages, ham	
Meat substitutes (including soya and Quorn)	
White fish and fish products	
Oily fish	
Roast/grilled/poached meat	
Meat dishes including spaghetti bolognaise, shepherd's pie and casseroles	
Beans and pulses (including hummus)	
Eggs and egg dishes e.g. quiche	
All fresh fruit except citrus	
Citrus fruits	
Tinned and cooked fruit	
Dried fruit	
Vegetables (except for tinned and salad)	
Salad vegetables	
Tinned vegetables	
Rice cakes	
Biscuits	
Crisps and savoury snacks	
Brown bread (including wholemeal)	
White bread	
Chocolate and sweets	
Other bread-type products e.g. bagels, muffins	
Breakfast cereals	
Potatoes and sweet potatoes	

Savoury biscuits and breadsticks	
Pizza	
Chips, roast and potato shapes	
Cakes (including pancakes, fruit breads)	
Gravy and savoury sauces	
Puddings and ice cream	
Marmite and Bovril	
Sweet spreads (including peanut butter)	
Added sugar	
Spreading fats e.g. butter or margarine	
Miscellaneous foods	

57. Please note approximately how many times each food was eaten in the previous 7 days in pureed form. If purees are not used, please leave blank

Baby dried cereals	
Baby biscuits/cookies	
Baby crisps/crackers	
Baby dried desserts	
Baby dried savoury meals	
Rusks	
Cheese	
Cows' milk and other non-baby milks	
Yoghurt or fromage frais	
Processed meat products e.g. sausages, ham	
Meat substitutes (including soya and Quorn)	
White fish and fish products	
Oily fish	
Roast/grilled/poached meat	
Meat dishes including spaghetti bolognaise, shepherd's pie and casseroles	
Beans and pulses (including hummus)	
Eggs and egg dishes e.g. quiche	
All fresh fruit except citrus	
Citrus fruits	
Tinned and cooked fruit	
Dried fruit	
Vegetables (except for tinned and salad)	
Salad vegetables	
Tinned vegetables	
Rusks	
Chocolate and sweets	
Breakfast cereals	
Potatoes and sweet potatoes	
Chips, roast and potato shapes	
Gravy and savoury sauces	
Puddings and ice cream	
Marmite and Bovril	
Sweet spreads (including peanut butter)	

Added sugar	
Spreading fats e.g. butter or margarine	
Miscellaneous foods	

58. When feeding pureed food, how often is food home-prepared (rather than shop-bought)?

- All or almost all the time
- Most of the time
- About half the time
- Less than half the time
- Rarely or never

59. How much does your baby enjoy the following foods (in either whole or pureed form, or as a drink)? Please check the most appropriate response.

	Dislikes a lot	Dislikes a little	Neither dislikes nor likes	Likes a little	Likes a lot	Hasn't tried it
Breast milk	☐	☐	☐	☐	☐	☐
Baby formula milk	☐	☐	☐	☐	☐	☐
Fruit juice (including baby juices)	☐	☐	☐	☐	☐	☐
Fruit squashes (including diet squash)	☐	☐	☐	☐	☐	☐
Tea and coffee	☐	☐	☐	☐	☐	☐
Fizzy drinks (including diet drinks)	☐	☐	☐	☐	☐	☐
Other drinks	☐	☐	☐	☐	☐	☐
Water	☐	☐	☐	☐	☐	☐
Cheese	☐	☐	☐	☐	☐	☐
Cows' milk and other non-baby milks	☐	☐	☐	☐	☐	☐
Yoghurt and fromage frais	☐	☐	☐	☐	☐	☐
Processed meat products e.g. sausages, ham	☐	☐	☐	☐	☐	☐
Meat substitutes (including soya and Quorn)	☐	☐	☐	☐	☐	☐
White fish and fish products	☐	☐	☐	☐	☐	☐
Oily fish	☐	☐	☐	☐	☐	☐
Roast/grilled/poached meat	☐	☐	☐	☐	☐	☐
Meat dishes including spaghetti bolognaise, shepherd's pie and casseroles	☐	☐	☐	☐	☐	☐
Beans and pulses (including hummus)	☐	☐	☐	☐	☐	☐
Eggs and egg dishes e.g. quiche	☐	☐	☐	☐	☐	☐
All fresh fruit except citrus	☐	☐	☐	☐	☐	☐
Citrus fruits	☐	☐	☐	☐	☐	☐
Tinned and cooked fruit	☐	☐	☐	☐	☐	☐
Dried fruit	☐	☐	☐	☐	☐	☐
Vegetables (except for tinned and salad)	☐	☐	☐	☐	☐	☐
Salad vegetables	☐	☐	☐	☐	☐	☐
Tinned vegetables	☐	☐	☐	☐	☐	☐
Rice cakes	☐	☐	☐	☐	☐	☐
Biscuits	☐	☐	☐	☐	☐	☐
Crisps and savoury snacks	☐	☐	☐	☐	☐	☐
Rusks	☐	☐	☐	☐	☐	☐
Brown bread	☐	☐	☐	☐	☐	☐

White bread	☐	☐	☐	☐	☐	☐
Chocolate and sweets	☐	☐	☐	☐	☐	☐
Other bread-type products e.g. bagels, muffins	☐	☐	☐	☐	☐	☐
Breakfast cereals	☐	☐	☐	☐	☐	☐
Potatoes and sweet potatoes	☐	☐	☐	☐	☐	☐
Savoury biscuits and breadsticks	☐	☐	☐	☐	☐	☐
Baby crisps/crackers	☐	☐	☐	☐	☐	☐
Baby dried cereals	☐	☐	☐	☐	☐	☐
Baby biscuits/cookies	☐	☐	☐	☐	☐	☐
Baby dried desserts	☐	☐	☐	☐	☐	☐
Baby dried savoury meals	☐	☐	☐	☐	☐	☐
Pizza	☐	☐	☐	☐	☐	☐
Chips, roast and potato shapes	☐	☐	☐	☐	☐	☐
Cakes (including pancakes, fruit breads)	☐	☐	☐	☐	☐	☐
Gravy and savoury sauces	☐	☐	☐	☐	☐	☐
Puddings and ice cream	☐	☐	☐	☐	☐	☐
Marmite and Bovril	☐	☐	☐	☐	☐	☐
Sweet spreads (including peanut butter)	☐	☐	☐	☐	☐	☐
Added sugar	☐	☐	☐	☐	☐	☐
Spreading fats e.g. butter or margarine	☐	☐	☐	☐	☐	☐

60. My baby generally accepts foods on the first taste

○ Strongly agree

○ Agree

○ Neither agree nor disagree

○ Disagree

○ Strongly disagree

61. If my baby doesn't like a food the first time, I don’t offer it again

○ Strongly agree

○ Agree

○ Neither agree nor disagree

○ Disagree

○ Strongly disagree

62. I try offering a food several times before I decided they don't like it

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

63. My baby enjoys trying new foods

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

64. I offer my baby a wide range of foods to try

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

65. I enjoy offering my baby new foods

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

This is the end of the questionnaire. Thank you very much for taking the time to complete it.
If you have any questions, please get in contact with the study coordinators listed below.
Please remember all responses will be treated confidentially.

Some people experience worries or concerns that arise as part of being a parent. It is possible that completing this questionnaire may have drawn your attention to problems you experience as a parent or caregiver. If you experiencing problems we would strongly advise you to contact your Health Visitor or GP. If they cannot help you they should be able to put you in contact with someone who can.

If you have any questions please do not hesitate to get in contact with Hannah Rowan or Dr Amy Brown in one of the following ways:

Hannah Rowan email: [redacted]

Dr Amy Brown email: [redacted]
Phone: [redacted]

66. We may conduct some more detailed follow up research on how babies are fed. If you would be willing to be contacted with details of the study as a possible future participant please enter your email address below. Your details remain confidential at all times and will not be passed on to any other persons or organisations.Thank you

What do babies *really* eat?
Investigating how babies are introduced to solids

Three day weighed food record and instruction booklet

Hannah Rowan MSc
Swansea University

Instructions for parents

1. Please fill in steps 1 to 6 for everything your baby eats and drinks as shown in the diary example on the following page. Try to fill in the diary during the day as your baby is eating/drinking rather than at the end of the day when your memory may not be so reliable!.
2. The days are counted from midnight to midnight, so please take a note of those night-time feeds.
3. Start each food and drink on a separate line
4. Please fill in the diary in as much detail as you can
5. For any queries, get in touch with Hannah Rowan or Dr. Amy Brown – our contact information is in the back of this information booklet.
6. Extra instructions can be found on page 12
7. And remember: please don't change what your child normally eats because you're filling in a diary – we are looking at "What babies REALLY eat"!

Step 1	Step 2			Step 3		Step 4				Step 5			Step 6	
Time of day	Name of food or drink	Brand of food or drink	Cooking method	Weight of plate/mug	Weight of food/drink and plate/mug	Consistency of food/drink				Food was placed into the child's mouth by:			Weight of leftovers + plate or mug	Estimate how much is left on plate/mug
						Pureed	Mashed	Diced	Whole	Adult	Child	Mixed		
Please write down the time your child had something to eat or drink, including am or pm.	Write down what they ate or drank	Include the brand (if any)	If cooked, how was the food cooked (steamed, fried, boiled etc.). If the food was coated, e.g. breadcrumbs, sauce or butter, please let us know. If a recipe was used please write "see recipe" and add the recipe to the section marked "Recipes"	Weigh an empty plate or cup using the scales provided. Note the weight here. If feeding from a jar, weigh it before and after food is given.	Put the food or drink on the plate/cup and place on the scales. Note the weight here. If several different foods are added to the plate, please write down the weights after each food is added.	Please tick the option that best fits the food you are giving. If the meal consists of different foods, please tick all that apply e.g. for a meal of baby rice and whole banana, you would tick "purred" and "mashed" for each food.				Please tick the section that best describes who fed the child, using "both" if both adult and child put food into the child's mouth.			After your child has eaten, place the plate or mug, including all their leftovers (including any that may have fallen on the floor or off the plate) on the scales and record the total weight of the plate and any food/drink left.	Estimate how much food was left (e.g. ¼ slice of toast, 1 tablespoon carrots)

Example Diet Diary (11 month old baby)

Step 1	Step 2			Step 3		Step 4				Step 5			Step 6	
Time of day	Name of food or drink	Brand of food or drink	Cooking method	Weight of plate/mug	Weight of food/drink and plate/mug	Consistency of food/drink				Food was placed into the child's mouth by:			Weight of leftovers + plate or mug	Estimate how much is left on plate/mug
						Pureed	Mashed	Diced	Whole	Adult	Child	Mixed		
6.30am	Breastfeed for 20 minutes				.									
8.30am	Breastfeed for 15 mins													
	White toast &	Hovis	toasted	50g	75g							√		Half
	Butter	Tesco				√								“
	Banana – half				175g							√	70g	None
						√								
10.30am	Breastfeed for 10 minutes													
12pm	Ella's Kitchen carrot crunchy snacks –bag (at café)	Ella's		n/a	15g								?	Half
										√				
						√								
	Strawberries (at café)				3 large									1/4
												√		
3pm	Water (at café)				4 sips									
						√				√				
	Fromage frais	Tesco			55g								10g	None
4pm	small carton													
												√		
4.30pm	Breastfeed 20 mins													
						√								

6pm	Fishfinger, cod	Tesco	Grilled	50g	110g	√	√		None
	Potato, 1 small		Boiled		185g		√		Most
	Frozen peas	Aldi	Boiled		215g	√	√	125g	Half
	Water			100g	200g	√	√	180g	Most
7pm	Breastfeed 15 mins								

Example Diet Diary (6 month old baby)

Step 1	Step 2			Step 3		Step 4				Step 5			Step 6	
Time of day	Name of food or drink	Brand of food or drink	Cooking method	Weight of plate/mug	Weight of food/drink and plate/mug	Consistency of food/drink				Food was placed into the child's mouth by:			Weight of leftovers + plate or mug	Estimate how much is left on plate/mug
						Pureed	Mashed	Diced	Whole	Adult	Child	Mixed		
7am	Bottle of formula (follow on)	Cow & Gate		115g	315g					√			300g	Little bit
8.30am	Jar baby rice cereal	Hipp		50g	80g	√				√			60g	Half
11am	Bottle of formula (follow on)	Cow & Gate		115g	355g					√			120g	None
1pm	Breadstick			25g	31g							√	28g	Half
	Fromage frais small	Sainsburys Petit Filous		n/a	20g	√				√			5g	None
	Banana			25g	50g	√		√		√			50g	All
3pm	Bottle of formula (follow on)	Cow & Gate		115g	315g					√			115g	None
5.30pm	Spaghetti bolognaise (pasta, mince, carrot, onion, tin toms, herbs)	Homemade	Pasta boiled, meat and veg in pan on stove	50g	115g	√				√			60g	¼
7pm	Bottle of formula (follow on)	Cow & Gate		115g	350g					√			130g	20ml?

Step 1	Step 2			Step 3		Step 4				Step 5			Step 6	
Time of day	Name of food or drink	Brand of food or drink	Cooking method	Weight of plate/mug	Weight of food/drink and plate/mug	Consistency of food/drink				Food was placed into the child's mouth by:			Weight of leftovers + plate or mug	Estimate how much is left on plate/mug
						Pureed	Mashed	Diced	Whole	Adult	Child	Mixed		

More instructions for participants:

1. Write down each time your baby has a breast or formula feed. For breast milk, please note approximately how long your baby nursed and for formula feeds please note the type and amount given.
2. If you don't have scales with you when you're away from home, please estimate the amount eaten e.g. small banana, handful of crisps
3. If your baby is eating food at a chain restaurant please give the name of the restaurant and portion e.g. Nandos, regular chips and kids apple juice
4. Consistency of food/drink:
    a. Pureed food has been blended using a food processor or blender for a completely smooth consistency
    b. Mashed food has been mashed by hand, e.g. with a fork, to make a lumpy (not entirely smooth) consistency
    c. Diced food has been chopped into lumps/small cubes
    d. Whole food has been served "as is" or cut into manageable hand held chunks e.g. a whole biscuit, carrot sticks, toast fingers, broccoli florets, a whole banana
5. When filling in Step 5, the parent/child column, if you have pre-filled a spoon but the child has put the spoon into their mouth, please tick "child"
6. In step 5, please fill both columns if there are times during a meal when both you and the child have out food into their mouth.
7. When estimating the total amount left at the end of a meal, please note what is left over for each food in the meal e.g. ¼ potato, all beans and no broccoli

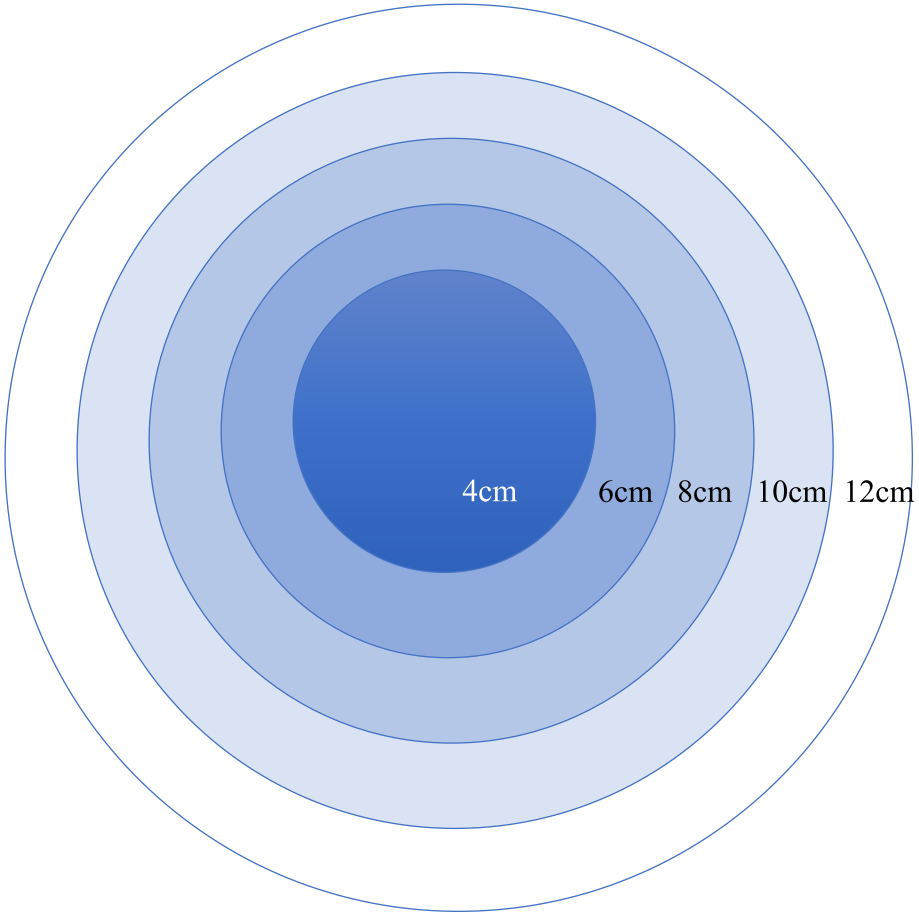
Estimating amounts of food offered when away from home or when you don't have your scale to hand:

1. Household measures such as tablespoons and teaspoons can be useful, especially if you can tell us whether you used a heaped or level spoonful.
2. Weights marked on packages: take a note of the weight of a prepacked food such as a smoothie pouch or crackers e.g. 60g Ella's Kitchen pouch.
3. The size of fruit and other round foods like biscuits and muffins can be estimated using the circles on the following page.
4. A ruler can be used to measure the size of cheese, meat biscuits or cakes. Just measure each side - including the depth or height! You'll be given a 15cm plastic ruler to help estimate food sizes when out and about
5. Fruit and veg can also be recorded using "small, medium and large" if other ways of measuring size aren't available.
6. Bread slices should be recorded as thin, medium or thick sliced.

Please note: we aren't looking for whether your child is eating a "healthy diet"! We need to find out what babies are actually eating. Please help us by being as honest and accurate as you can.

Estimating food on the go

You can use this guide to estimate food size: place the food on the circles below and take a note of how big the piece of food is.



Photos
You can take photos of the food your baby is offered and any leftovers if you're are unsure of sizes and have no other way of measuring a meal.

This is the end of the questionnaire. Thank you very much for taking the time to complete it. If you have any questions, please get in contact with the study coordinators listed below. Please remember all responses will be treated confidentially.

Some people experience worries or concerns that arise as part of being a parent. It is possible that completing this questionnaire may have drawn your attention to problems you experience as a parent or caregiver. If you experiencing problems we would strongly advise you to contact your Health Visitor or GP. If they cannot help you they should be able to put you in contact with someone who can.

If you have any questions please do not hesitate to get in contact with Hannah Rowan or Dr. Amy Brown in one of the following ways:

Hannah Rowan email: [redacted]

Dr. Amy Brown email: [redacted]

<u>What do babies *really* eat? A study on the diets of babies 6-12 months</u>

Some information about you: please fill in as accurately as possible. All answers will be made anonymous. If you would be happy to be contacted in the future for research purposes, please give a code word so that your details can be identified:

Name:

1. Are you your child's Mother ☐
   Father ☐

2. How old are you?

3. What is your highest level of education? Please tick the box.

No formal qualifications	
GCSE level or equivalent	
A level or equivalent	
Degree level or equivalent	
Postgraduate or equivalent	

4. Are you currently working?

Full time	
Part time	
Maternity leave (will return)	
Maternity leave (won't return)	
Not working	

5. What is your ethnic background?

White (British, Irish)	
Gypsy or Irish traveller	
Mixed ethnicity	
Asian	
Chinese	

Black/African/Caribbean/Black British	
Arab	
Other (please specify)	

6. Which of the following best describes your current relationship status?

Married	
Widowed	
Divorced	
Separated	
Living with your partner/civil union	
Single	

7. Is you baby a boy or girl? Boy ☐
   Girl ☐

8. What is your baby's age in weeks

9. What was the birth weight of your baby?

10. What is your baby's weight now?

11. What milk are you feeding your baby? Please tick all that apply?

Breast feeding	
Formula feeding	
Mix of breast and formula	
Expressed breast milk	
Cow's milk	
Dairy alternative e.g. soya milk	
No milk	

12. How old was your baby when you introduced solid foods in weeks?

13. Baby led weaning is the process of placing foods in front of your baby and letting them feed themselves – picking the food up themselves and

putting it in their mouths unassisted, rather than being spoon-fed by a parent. This could involve them using a spoon themselves. Baby-led weaning tends to involve offering the baby whole, family foods rather than pureed foods.

Looking at the description above, would you say that you are following Baby-led weaning?

Yes - strictly	
Yes - loosely	
No	
Don't know	

14. When your baby is in your care, how would you describe the method of feeding?

Spoon fed by an adult	
Predominantly spoon feeding, very occasional baby-led feeding	
Mostly spoon-fed by an adult, some baby led feeding	
About half spoon feeding by an adult and half baby-led feeding	
Mostly baby led feeding, some spoon-feeding by an adult	
Predominantly baby-led, very occasional adult spoon feeding	
Baby-led feeding	

15. When your baby is in your care, how would describe the type of food they eat? Finger foods refer to non-pureed foods in their whole form e.g. a piece of toast, pasta shape, cooked broccoli spear

Pureed food or baby rice etc	
Predominantly pureed food, very occasional finger food	
Mostly pureed food, some finger foods	
About half purees and half finger foods	
Mostly finger foods and some purees	

Predominantly finger foods, very occasional pureed food	
Finger foods	

16. Has the way you feed your baby changed from the start of weaning?

No	
Yes – they are eating more pureed food and less finger foods	
Yes – they are eating more finger foods and less purees	
Yes – I used to give purees but have completely stopped now	

17. What proportion of your baby's diet would you estimate is solids compared to milk?

Thank you for your time and taking part in this study, your help is really appreciated!

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2014-2015

DEPARTMENT OF PSYCHOLOGY

APPLICATION FOR RISK ASSESSMENT AND ETHICAL APPROVAL

PLEASE COMPLETE THE FORM USING TYPESCRIPT

(handwritten applications will not be considered)

Name	Hannah Rowan	Student Number (if applicable)	[redacted]
Address	[redacted]		
University E-mail address	[redacted]		
Title of Proposed Research	Nutritional intake and eating behavior of infants during the weaning period		
Type of Researcher (please tick)	☐ Undergraduate student ☐ MSc student - Abnormal and Clinical Psychology ☐ MSc student - Research Methods in Psychology ☐ MSc student - Cognitive Neuroscience X PhD student ☐ Member of staff For MSc students only: This ethics application is for: (please tick) ☐ Empirical Project 1 ☐ Empirical Project 2 ☐ Empirical Project 3 ☐ 60 credit project		
Name of supervisor	Dr Amy Brown, Dr Michelle Lee		

RECEIVED 02 OCT 2014 PSYCHOLOGY DEPARTMENT

1. Briefly describe the main aims of the research you wish to undertake. Please use non-technical language wherever possible.

Babies are traditionally introduced to solid foods at around six months using spoon feeding and pureed foods. Recently an approach known as baby-led weaning is growing in popularity. Here infants self feed family foods – no spoons or purees are involved.

Although this approach is growing in popularity with a number of books, videos and online forums, there has been little research of the use or outcomes of the approach. Recent work suggests that babies weaned using a baby-led approach are less likely to be overweight and fussy eaters as toddlers than those weaned using a traditional approach. However, given the little research that has been completed, the method is not formally recognized by the Department of Health.

A further reason for this lack of recognition is that little is known about the nutritional intake of these babies. Proponents of the method suggest that babies thrive on the approach but we do

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16.	Will participants be informed of the right to withdraw without penalty?	Yes	X
		No	☐
If no, please detail the reasons for this:			

17.	How do you propose to ensure participants' confidentiality and anonymity?

Online data collection will promote anonymity. All identifying information will be removed from the responses. No identifying information will be used in publications.

18.	Please describe which of the following will be involved in your arrangements for storing data:

- X☐ Manual files (e.g. paper documents or X-rays)
- X☐ Home or other personal computer
- X University computer
- ☐ Private company or work-based computer
- ☐ Laptop computer
- ☐ Other (please define)

Please explain, for each of the above, the arrangements you will make for the security of the data (please note that any data stored on computer must have password protection as a minimum requirement):
Any paper responses will be kept in a locked filing cabinet with data files stored on a password protected computer.

19.	Will payments or subject pool credits be made to participants?	Yes	☐
		No	X
If yes, please specify quantities involved (e.g., £5 or 1 hour credits):			

Applicant's signature: [redacted] Date: 1 October 2014

Supervisor's signature: [redacted] Date: 02/10/14.

PLEASE SUBMIT ALL APPLICATIONS FOR ETHICAL APPROVAL VIA JACKIE SCHOLZ, ROOM 801

****RESEARCH MAY ONLY COMMENCE ONCE ETHICAL APPROVAL HAS BEEN OBTAINED****

[redacted] 22/oct 2014

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DEPARTMENT OF PSYCHOLOGY

APPLICATION FOR RISK ASSESSMENT AND ETHICAL APPROVAL

PLEASE COMPLETE THE FORM USING TYPESCRIPT

(handwritten applications will not be considered)

Name	Hannah Rowan — Student Number (if applicable) [redacted]
Address	
University E-mail address	[redacted]
Title of Proposed Research	Health Professional and Nutritional experts' attitudes and experiences towards baby-led weaning
Type of Researcher (please tick)	☐ Undergraduate student ☐ MSc student - Abnormal and Clinical Psychology ☐ MSc student - Research Methods in Psychology ☐ MSc student - Cognitive Neuroscience X PhD student ☐ Member of staff **For MSc students only**: This ethics application is for: (please tick) ☐ Empirical Project 1 ☐ Empirical Project 2 ☐ Empirical Project 3 ☐ 60 credit project
Name of supervisor	Dr Amy Brown; Dr Michelle Lee

1.	Briefly describe the main aims of the research you wish to undertake. Please use non-technical language wherever possible.

Babies are traditionally introduced to solid foods at around six months using spoon feeding and pureed foods. Recently an approach known as baby-led weaning is growing in popularity. Here infants self feed family foods – no spoons or purees are involved.

Although this approach is growing in popularity with a number of books, videos and online forums, there has been little research of the use or outcomes of the approach. Recent work suggests that babies weaned using a baby-led approach are less likely to be overweight and fussy eaters as toddlers than those weaned using a traditional approach. However, others have concerns about the method; that it might lead to choking or malnutrition (although these are not evidenced).

At present the method is not recognized by the Department of Health due to a lack of evidence to build policy upon. Research has explored parental attitudes towards the method but has not

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CHECKLIST OF ATTACHMENTS:
PLEASE REMEMBER TO ATTACH COPIES OF EACH OF THE FOLLOWING (WHERE RELEVANT)

INCOMPLETE APPLICATIONS WILL NOT BE CONSIDERED

- ☑ Copy of Participant Information Sheet
- ☑ Copy of Consent Form
- ☑ Copy of Participant debrief
- ☑ Copy of any questionnaires and/or interview schedules to be employed
- ☐ Copy of written consent from local authorities (e.g., schools)
- ☐ If your proposed research is with 'vulnerable' groups (e.g., children, people with developmental disorder), please attach a copy of your clearance letter from the Criminal Records Bureau (if UK) or equivalent non-UK clearance.

As a member of the Departmental Ethics Committee, I have scrutinized this application. In my opinion some elements are under-developed and require attention. The application is therefore returned to you as the student's supervisor.

Please tick if appropriate ☐

Departmental Ethics Committee Use Only

Members of the Departmental Ethics Committee have considered the ethical issues raised by this project, and have the following comments:

Fine – [illegible] project – no [illegible]

Please ensure that you take account of these comments and prepare a revised submission that should be either shown to your supervisor (if you are an undergraduate or postgraduate student) or resubmitted (if you are a member of staff) to the Departmental Ethics Committee.

Signed on behalf of Departmental Ethics Committee:

[redacted]

Date: 12/12/2014

GJ-B

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2016-2017

DEPARTMENT OF PSYCHOLOGY

APPLICATION FOR RISK ASSESSMENT AND ETHICAL APPROVAL

PLEASE COMPLETE THE FORM USING TYPESCRIPT

(handwritten applications will not be considered)

Name of Supervisor (Staff Member)	Dr. Amy Brown
Supervisor university email	[redacted]
Name(s) and Number(s) of All Students Involved	Hannah Rowan [redacted]
Title of Proposed Research	Nutritional intake and eating behavior of infants during the weaning period.
Type of Research (please tick all that apply)	☐ Undergraduate ☐ MSc - Abnormal and Clinical Psychology ☐ MSc - Research Methods in Psychology ☐ MSc - Cognitive Neuroscience x PhD ☐ Staff **For MSc students:** This ethics application is for: (please tick) ☐ Empirical Project 1 ☐ Empirical Project 2 ☐ Empirical Project 3 ☐ 60 credit project
Level of risk (see decision tree)	x This research is a negligible risk project ☐ This research is a low risk project ☐ This research is NOT a low risk project

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1. Briefly (max 200 words) describe the research you wish to undertake: Include study rationale, main theoretical constructs, and hypotheses. Please use non-technical language wherever possible.
Babies are traditionally introduced to solids at around six months using spoon-feeding and pureed foods, but an approach known as baby-led weaning (BLW), whereby infants self feed family foods, is growing in popularity. Although there are print and online resources dedicated to BLW, there has been little research on its use or outcomes. Recent work suggests that babies weaned using BLW are less likely to be overweight and fussy eaters as toddlers than traditionally weaned babies. However, little is known about the nutritional intake of BLW babies and whether they are eating enough. Preliminary findings by the study author suggest that there are few significant differences in the portions of different foods that BLW babies are eating compared with traditionally weaned babies, however to ascertain whether their macro and micronutrient intakes differ, a more in depth analysis is required. One recent New Zealand study, found significant differences in consumption

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CHECKLIST OF ATTACHMENTS:
PLEASE REMEMBER TO ATTACH COPIES OF EACH OF THE FOLLOWING (WHERE RELEVANT)

"INCOMPLETE APPLICATIONS WILL NOT BE CONSIDERED"

x Copy of Participant Information Sheet
x Copy of Consent Form
x Copy of Participant debrief
x Copy of any questionnaires and/or interview schedules to be employed
☐ Copy of written consent from local authorities (e.g., schools)
☐ If your proposed research is with 'vulnerable' groups (e.g., children, people with developmental disorder), please attach a copy of your clearance letter from the Criminal Records Bureau (if UK) or equivalent non-UK clearance.

As a member of the Departmental Ethics Committee, I have scrutinized this application. In my opinion some elements are under-developed and require attention. The application is therefore returned to you as the student's supervisor. — Please tick if appropriate ☐

Departmental Ethics Committee Use Only

Members of the Departmental Ethics Committee have considered the ethical issues raised by this project, and have the following comments:

Approved

Please ensure that you take account of these comments and prepare a revised submission that should be either shown to your supervisor (if you are an undergraduate or postgraduate student) or resubmitted (if you are a member of staff) to the Departmental Ethics Committee.

Signed on behalf of Departmental Ethics Committee:

[redacted] Date: 19.04.2017

Were there any significant safety issues that needed resolving? Yes ☐ No ☑

If YES: College Safety Officer Approval (Mark Hughes):

[redacted] Date: [redacted]

NOTE TO LEVEL 3 UNDERGRADUATE PROJECT STUDENTS, MSc and PhD STUDENTS: PLEASE INCLUDE A SIGNED COPY OF YOUR ETHICS APPLICATION FORM, ALL SUPPORTING DOCUMENTS AND CONFIRMATION LETTER OF APPROVAL, AS AN APPENDIX IN YOUR FINAL YEAR PROJECT OR THESIS.

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