

An evaluation of the impact of school food standards in England on children's diets

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Abstract

Background

Many children do not eat a healthy diet. In 2005, the nutritional content of school lunches in England received wide criticism. In 2006, a major policy change led to legislation specifying what food and drink could, and could not, be served in schools. This thesis considers the impact of the implementation of food and nutrient-based standards on children's dietary intake at lunchtime and in their total diet, if the impact was equitable across the socio-economic spectrum, and if school lunch take-up changed.

Methods

Data collected pre and post-policy implementation in children aged 4-7y and 11-12y were analysed. In the 4-7y olds, dietary data were collected on four consecutive days using an observational method in 12 primary schools, in Newcastle upon Tyne, UK ($n=385$ in 2003-4; $n=632$ in 2008-9). In 11-12y olds, dietary data were collected from two consecutive 3-day food diaries followed by a researcher-led interview in six middle schools, in Northumberland, UK ($n=298$ in 1999-2000; $n=215$ in 2009-10). Linear mixed effect models were used to analyse the effects of year (pre and post-policy), lunch type (school or home-packed lunch), level of socio-economic deprivation, and the interaction(s) between these factors on children's total dietary intake. Logistic regression was used to examine the change in school lunch take-up by year and level of deprivation.

Results

At lunchtime, children who ate a school lunch post-policy implementation consumed a lower per cent energy from fat, saturated fat and absolute amounts of sodium. In the 4-7y olds, mean calcium (mg), vitamin C (mg) and iron (mg) intakes increased; in 11-12y olds, non-starch polysaccharides (g) and iron (mg) decreased. A child's lunch type was associated with change in the total dietary intake in 4-7y olds; post-policy implementation children eating a school lunch had a healthier total diet compared with children eating a home-packed lunch. In 11-12y olds, there was limited evidence found that lunch type was associated with change in total diet. In both age groups children's total dietary intake from

per cent energy saturated fat and non-milk extrinsic sugars remained above the recommended guidelines. There was some evidence that post-policy implementation, lunch type and level of deprivation were associated with differences in per cent energy from non-milk extrinsic sugars and vitamin C (mg) intake in the total diet of 4-7y olds; there was no such evidence found in 11-12y olds. Post-policy implementation, school lunch take-up decreased in both age groups.

Conclusions

The implementation of school food and nutrient-based standards in England has been associated with positive changes in children's dietary intake at lunchtime. These changes were reflected in the total diets of the 4-7y olds but evidence was more limited in 11-12y olds. A key strength of this study is the unique evaluation of national policy enabled by the availability of pre-implementation data. A key limitation is the use of repeat cross-sectional surveys; this limits the extent to which change in children's diets can be attributed to the policy. Future regulation of school lunches should be evaluated prospectively. To improve children's diets in all their complexity, future interventions also need to consider the social, environmental and behavioural contexts in which food choices are made or directed, both in and outside of the school environment.

Acknowledgements

There are a lot of people who facilitated at various points during this PhD. Firstly, my thanks to the schools, parents and children who participated and were a pleasure to work with.

To Prof Ashley Adamson, I would never have considered a PhD without your encouragement! Thank you for always focusing on the positives and for both your personal and professional support and guidance. Prof John Matthews, you have taught me a huge amount. Sincere thanks for your unending patience, time and support with the statistical analysis. Prof Martin White, thank you for your comments throughout this process.

The dietary data collection, coding and entering was a considerable task and I would like to thank a number of colleagues in achieving this: Katherine Young for her attention to detail in entering the data; Jen Bradley for her patience in assigning food weights to the middle school children's diaries; Pauline Winship and the 'school food study' team for making the dietary data collection in primary schools so enjoyable. Thanks to the Research Advisory Team that included members from: the Department of Health (Public Health Research Consortium), Newcastle and Northumberland County Councils, the School Food Trust and Professor Andrew Rugg-Gunn for his valuable contributions and comments on draft papers. My thanks to IHS and the All Saints Educational Trust for the funding received.

Huge thanks to a great bunch of friends that kept (keep!) me sane. Thank you for your listening skills (!), valued distractions and reminding me this would end...especially these last few months! To my fantastic family '*the Spence's*' what can I say?! Always there for me no matter what - thank you is inadequate. WhatsApp has provided many smiles over the last months seeing the 'little' men in my life. Finally, in loving memory of Jonathan Tate. I sometimes forget what is important in life, and especially during those times I remember you.

Declaration

I hereby declare that the work comprising this thesis is my own work. I have correctly acknowledged any work of others, in accordance with University and Institute guidance on good academic conduct, and that no part of the material offered has been previously submitted for a degree or other qualification in this or any other university. Where joint work is submitted in the papers my independent contribution has been outlined in the appropriate co-authorship forms and during the paper submission process.

Signature

Date

Statement of research contributions

Study design

The study design and methods employed were principally developed by Professor Ashley Adamson assisted by Professor Martin White. The ethical application was near completion at the start of my employment and had been undertaken by Professor Ashley Adamson. In 2009-2010, due to a change in the recruitment procedure used in the middle schools (11-12y olds) dietary survey an amendment to the original ethics was required. This amendment was undertaken by me with guidance from Professor Ashley Adamson.

Dietary data collection and coding

I was responsible for the dietary data collection in 2007-2008 & 2008-2009 in the 4-7y olds, and in 2009-2010 in the 11-12y olds. In the 4-7y olds the dietary data collection method required a number of individuals to assist. I was responsible for the training and supervision of a team of trained observers to assist at schools with the dietary data collection. Alison Hossack was responsible for the dietary data collection in 11-12y olds in 2007-2008.

I carried out all nutritional coding of the 4-7y old diaries and for the 11-12y olds in 2008-2009. In 2007-2008, in the 11-12y olds, Alison Hossack completed this. The method to ensure consistency in dietary coding is discussed in detail in Chapter 4. Checking of consistency was aided by colleagues Katherine Young and Jennifer Delve. Dietary data entry of nutritional records in 4-7y and 11-12y olds was largely performed by Katherine Young. Jennifer Delve, Emma Simpson and I contributed to the 11-12y data entry and duplicate dietary data entry for both age groups. The method to apply food weight in the 11-12y olds was undertaken by Jennifer Delve.

Statistical analysis

The statistical analysis was performed by me with guidance from Professor John Matthews, and in the earlier stages from Elaine Stamp. I initially interpreted the results and this was included in the preparation of the papers for co-author comments.

Co-authorship on papers

I am first author and lead on the papers included in this submission. All co-authorship has been declared on the forms required for submission of this thesis by publication. All co-authors signed to agree the percentage contribution I made for the: design of investigation, conduct of research, analysis of outcome and preparation for publication. During each paper submission to the journals I also outlined co-author contributions.

Co-authorship on report submitted to the Department of Health (Public Health Research Consortium)

During my time as a Research Assistant and PhD student a project report was submitted to the Department of Health (Public Health Research Consortium) as funders. I co-authored this report and undertook analysis presented therein with assistance from Elaine Stamp and guidance from Professor John Matthews. Reference to the report is made in this doctoral statement. Additional analysis and research questions were included in the first four author papers submitted in this doctoral statement.

Preface

I started my career as a paediatric nurse working in the NHS. During my employment I was granted a one-year career break to manage a paediatric department in Zambia. Here I saw the extreme signs and symptoms of many health conditions; one of those was the effects of malnutrition. I developed a real interest in the nutritional status of children and its impact on their health. We frequently treated and managed severely malnourished children to achieve a 'target weight' deemed acceptable for discharge. However, it was usually only a matter of weeks or months before they were re-admitted. There was a realisation we were addressing a very small issue and then discharging them to an environment on which we had little influence on. In 2005, I attended London School of Hygiene & Tropical Medicine and completed an MSc in Public Health Nutrition. One topic I particularly enjoyed was public health policy. In 2007, I applied for a Research Assistant position at Newcastle University to work on a study that would develop research skills in evaluating a change in policy to school food in England. This post offered me an opportunity to be involved in examining the effect of a policy-level intervention (something I was particularly interested in after my experience in Zambia) to address one aspect of child health: children's diets. Subsequently, I have had the opportunity to use these data to pursue this thesis by publication for which I am grateful.

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List of Publications

This thesis is based on the work presented in the following papers:

- I. **Spence S**, White M, Adamson AJ and Matthews JNS (2014) Does the use of passive or active consent affect consent or completion rates, or dietary data quality? Repeat cross-sectional survey among school children aged 11-12years.
BMJ OPEN 2014;4:e006457. doi:10.1136/bmjopen-2014-006457
- II. **Spence S**, Delve J, Stamp E, Matthews JNS, White M and Adamson AJ (2013) The Impact of Food and Nutrient-Based Standards on Primary School Children's Lunch and Total Dietary Intake: A Natural Experimental Evaluation of Government Policy in England.
PLoS ONE 8(10): e78298. doi:10.1371/journal.pone0078298
- III. **Spence S**, Delve J, Stamp E, Matthews JNS, White M and Adamson AJ (2014) Did school food and nutrient-based standards in England impact on 11-12y olds nutrient intake at lunchtime and in total diet? Repeat cross-sectional study.
PLoS ONE 9(11): e112648. doi:10.1371/journal.pone0112648
- IV. **Spence S**, Matthews JNS, White M and Adamson AJ (2014) A repeat cross-sectional study examining the equitable impact of nutritional standards for school lunches in England in 2008 on the diets of 4-7y olds across the socio-economic spectrum.
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Abbreviations

CCT	Compulsory Competitive Tendering
CI	Confidence interval
COMA	Committee on the Medical Aspects of Food Policy
CRB	Criminal Records Bureau
CWT	Caroline Walker Trust
DRV	Dietary Reference Value
FAST	Food Assessment in Schools Tool
g	Grams
ID	Identification number
i.e.	<i>id est</i>
IMD	Index of Multiple Deprivation
kcal	Kilocalories
LEAs	Local Education Authorities
mg	Milligrams
n	Number
NCMP	National Child Measurement Programme
NDNS	National Diet and Nutrition Survey
NHS	National Health Service
NMES	Non-milk extrinsic sugars
NSP	Non-starch polysaccharide
OR	Odds ratio
PL	Packed lunch
%	Percentage
% E	Per cent energy
RCT	Randomised control trial
RNI	Reference Nutrient Intake
SACN	Scientific Advisory Committee on Nutrition
SES	Socio-economic Spectrum
SL	School lunch
SMRP	School Meal Review Panel
µg	Microgram
UK	United Kingdom
USA	United States of America
WHO	World Health Organization
y	Year

Chapter 1 Introduction

It is now well recognised that what children eat has an important influence on child health.¹⁻³ The World Health Organization have defined a 'healthy' diet as one that contains more fruit, vegetables, legumes, nuts and grains, and less salt, sugar and fat.⁴ However, a number of national reports highlight that what children eat does not meet recommended guidelines.⁵⁻⁸ As well as children's diets containing too much saturated fat, sugars and a lack of fruit and vegetables, childhood overweight and obesity has increased over the last few decades.^{9, 10} Improving what children eat is central to achieve a 'healthier' lifestyle, and as part of this, reduce childhood overweight and obesity.^{11, 12} Identifying solutions is more complex. One focus has been on the school environment and what children eat at school. In England, food and nutrient-based standards were introduced for school lunches that specified what food and drink could and could not be served. Primary schools had to comply with the legislation in September 2008 and secondary schools in September 2009.¹³ Following this major policy change to school food in England it was important to evaluate the impact of implementing food and nutrient-based standards on children's diets. Four published papers are included in this doctoral statement as listed on page xvi. Three focus on evaluating the impact of the food and nutrient-based standards to school lunch on children's diets and one on a methodological aspect of the study.

Research questions addressed

Dietary

1. Did the introduction of food and nutrient-based standards impact on lunchtime and total dietary intake in children aged 4-7y and 11-12y? (Paper II and III)
2. Did the introduction of nutritional standards for school lunches have an equitable impact on children's diets across the socio-economic spectrum? (Paper II and IV)
3. Did school lunch take-up change across the socio-economic spectrum following the introduction of food and nutrient-based standards? (Paper II and IV)

Methodological

4. Did the use of passive or active consent affect consent and completion rates, or dietary data quality across the socio-economic spectrum? (Paper I)

Overview of structure of doctoral statement

The intention of this doctoral statement is to provide a narrative on the context for the papers, review the current literature and reflect on the implementation and evaluation of the food and nutrient-based standards to school lunch in England.

I begin by setting the wider context of child health and the importance of a healthy diet for children. A short historical outline of school meals in England is presented to set the policy context (Chapter 2). This is followed by a narrative review of the current literature that examines the impact of a child's lunch type (school or home-packed lunch) on their dietary intake at lunchtime, in their total diet and across the socio-economic spectrum. The limitations of the current literature are summarised and the rationale and research questions are stated (Chapter 3). Chapter 4 provides a more detailed account of the dietary data collection methods employed than reported in the individual papers. As Paper I focuses on a methodological aspect of this study it is included in this chapter. A summary of the key dietary findings and the inclusion of Papers II, III and IV are presented in Chapter 5. In the final chapter (Chapter 6) I provide a brief summary of the key findings, the relationship to other studies and the key strengths of the papers. I reflect on the implementation of the food and nutrient-based standards and discuss the wider limitations to the body of work evaluating the impact of nutritional standards on children's diets. The key policy implications and areas for future research are considered. To finish, some concluding remarks are also in this chapter (Chapter 6).

Chapter 2 Background

Chapter overview:

This chapter gives a brief overview on child health and the importance of a 'healthy' diet for children. It discusses the role of children's diets as one contributing factor to childhood overweight and obesity. Reference is made to the fact that many factors influence children's diets. While improving what children eat is important, identifying solutions is a challenge. One focus has been on the school environment and the food and drink served at schools. The chapter finishes by setting out the policy context and historical events in school meals that led to the implementation of food and nutrient-based standards to school lunch in England.

2.1 Child health: an overview

Over the last few centuries there have been many advances in child health. In the 20th Century, improved water and sanitation, immunisation and nutrition were influential, along with medical advances.¹⁴ By the mid-20th Century the focus was on adult health and it was not until the later part of the 20th century that there was a re-emergence of interest in child health.¹⁴ This was associated with a number of studies: the 1000 family study in Newcastle, 1947 and the national birth cohort studies in 1946, 1958, 1970 and 2001. These studies recognised several themes, such as the importance of child health on health in later life.¹⁴ The emergence of childhood obesity has also led to a re-focus on child health^{15, 16} A persistent challenge for child health is children's diets, albeit for different reasons to those at the start of the 20th Century. The focus on children's diets has shifted from under- to overnutrition.

2.2 Children's diets

It is now well recognised that children's dietary intake has an important influence on child health.¹⁻³ What children eat is central to optimal health and potentially contributes to the prevention of cardiovascular disease, stroke and

type II diabetes in later life.¹ Furthermore, eating behaviours that are developed in childhood have been found to continue into adulthood.^{1, 17} Therefore, childhood is an important period to establish a 'healthy' diet.

What constitutes a 'healthy' diet has been defined by the World Health Organization as a diet that contains more fruit, vegetables, legumes, nuts and grains, and less salt, sugar and fat.⁴ In the UK a key tool to provide information about a 'healthy' diet to the general population is through the use of the Eatwell plate.¹⁸ The Eatwell plate is a visual tool developed by the Food Standards Agency in 2007 to illustrate how a combination of foods contributes towards a 'healthy' diet. The pictorial image was developed to show that some foods may need to be consumed more than others, for example, fruit and vegetables; and some foods may need to be consumed less, for example, sweets, cakes and biscuits.¹⁹ Similarly, the Change4Life campaign provides information about a 'healthy' diet through messages about '5-A-Day', 'watch the salt', 'cut back fat' and 'sugar swaps'.²⁰

These food-based dietary guidelines are useful for the general population and reflect how foods rather than nutrients are eaten. However, both food and nutrient-based guidelines have been formulated and underpinned by scientific recommendations guided by expert panels such as the: Committee on the Medical Aspects of Food Policy (COMA), World Health Organization (WHO) and Scientific Advisory Committee on Nutrition (SACN). These organisations review the available evidence as a basis for recommendations for intake of nutrients and specific foods to prevent deficiencies and promote optimal health. For example, in 1991, COMA provided estimated average requirements for energy, and macro- and micronutrient recommendations for the UK population;²¹ in 2003, WHO recommended a mean daily intake of 400g of fruit and vegetables,^{1, 22} and in 2011, SACN reviewed and updated the guidance on energy requirements.²³ In March 2014, WHO advised that consumption of free sugars added to food or naturally present in honey, syrups, fruit juices and fruit concentrates should be reduced.²⁴ WHO conditionally recommended that free sugar intake be reduced to below 5% of total energy.²⁵ In response, SACN has provisionally advised a reduction;²⁶ this will be reviewed in February 2015. Dietary recommendations for children aged 4-7y and 11-14y in the United

Kingdom (UK) are shown in Table 1; where relevant these are shown for age and gender.

Table 1 Recommendations for energy, food energy, nutrients and fruit and vegetable intakes for children aged 4-7y and 11-14y in the UK

Food/Nutrient	Recommendations			
	4-7y		11-14y	
	Male	Female	Male	Female
Energy (kcal)*	1715	1545	2220	1845
Fat (%)†	No more than 35% food energy			
Saturated Fat (%)	No more than 11% food energy			
NMES (%)	No more than 11% food energy‡			
Protein (g)§	19.7		42.1	41.2
Sodium (g)	700		1600	1600
Calcium (mg)	450		1000	800
Iron (mg)	6.1		11.3	14.8
Zinc (mg)	6.5		9.0	9.0
Vitamin C (mg)	30		35	35
Vitamin A (µg)	400		600	600
Folate (µg)	100		200	200
Fruit & Vegetables¶ (portion/g)	At least 5 portions per day (equivalent to 400g)			

*Estimated Average Requirements for energy²¹

†Dietary Reference Values for food energy²¹

‡Conditional recommendation from WHO and likely to be recommended by SACN is free sugars be reduced to below 5% of total energy^{25, 26}

§Reference Nutrient Intake²¹

¶WHO recommendation^{1, 22}

Despite recommendations, there have been a number of national reports that highlight that what children eat does not meet all these recommendations.⁵⁻⁸ In 1989, findings from the 'Diets of British School Children'⁵ survey highlighted children's mean intakes of fat were above the recommendations and mean intakes of micronutrient were below.⁵ A study by Prynne *et al*, 1999²⁷ compared data from the National Diet and Nutrition Survey (1992/93) with the Medical Research Council (MRC) National Survey of Health and Development (1946 birth cohort). They found that children aged 4y had higher intakes of per cent

energy from sugar and lower mean intakes of micronutrients compared with children in 1950. More recently, key findings from the National Diet and Nutrition Survey (NDNS) 2008/09-2011/12²⁸ are shown in Table 2. Per cent energy from saturated fat and NMES were above the recommendations for children aged 4-10y and 11-18y. For the 4-10y olds, mean micronutrient intakes were within the recommendations. In contrast, for the girls aged 11-18y mean micronutrient intakes were below the recommendations. Mean fruit and vegetable intakes *including fruit juice* and *not including fruit juice* were below the recommendation in both age groups.²⁸ Therefore, the advice by the World Health Organization that a 'healthy' diet contains more fruit and vegetables, and less sugar and fat is currently not reflected in the average child's diet in the UK. Of concern, is that children's per cent energy from NMES is three times higher than the conditional recommendation of reducing free sugars to below 5% of total energy by WHO, which is likely to be adopted by SACN.^{25, 26}

Table 2 Children's mean nutrient and fruit and vegetable intake from the NDNS 2008/9 to 2011/12 (aged 4-10 and 11-18y)

Food/Nutrient	4-10y	11-18y	
	All	Male	Female
Energy (kcal)	1532	1972	1569
Fat (%)	33.4	33.8	34.2
Saturated Fat (%)	13.2	12.7	12.4
NMES (%)	14.7	16.0	15.2
Calcium (mg)	803	889	670
Iron (mg)	8.7	10.7	8.4
Zinc (mg)	6.4	8.3	6.3
Vitamin A (µg)	651	725	596
Folate (µg)	195	233	186
Fruit & Vegetables (g) <i>not including fruit juice</i>	205	177	166
Fruit & Vegetables (g) <i>including fruit juice</i>	316	288	261

There is also evidence of socio-economic disparities in children's diets with those from more deprived families having 'poorer' diets.^{29 30, 31} For example,

children in more deprived families have been found to have lower intakes of micronutrients and fruit and vegetables, and higher intakes of energy-dense drinks.^{30 31} As well as children's diets containing too much saturated fat, sugars and a lack of fruit and vegetables, there has been an increase in childhood overweight and obesity during the last few decades.^{9, 10} While fundamentally an issue of energy balance the causes of childhood obesity are multi-faceted and complex; one potentially contributing factor is an 'unhealthy' diet.^{1, 2} Improving what children eat and developing 'healthier' eating habits is central to achieve a 'healthier' lifestyle, and as part of this, reduce childhood overweight and obesity.^{11, 12} Despite signs that childhood obesity is levelling,^{32, 33} in 2011-12, The National Child Measurement Programme (NCMP) in England found one in five 4-5y olds and one in three 10-11y olds were overweight or obese.³⁴ Being overweight and obese has a number of implications which have personal and societal impacts. For individual health, childhood obesity has been found to persist into adulthood and is associated with long term health consequences as noted in section 2.2.¹ In 2007, the Foresight report highlighted the economic costs to the National Health Service (NHS) and society. By 2050, the NHS costs associated with overweight and obesity are estimated at £10billion per year; the economic cost to society is predicted to be much higher.²

2.3 Factors influencing children's dietary intake and the role of schools

What children eat is influenced by a number of factors and so identifying appropriate solutions has proved challenging.^{2, 29, 35-37} Story *et al*, 2008³⁸ use an ecological framework, which illustrates that food choice and eating behaviours are affected by multiple levels of interconnecting factors: individual (i.e. age, lifestyle, skills and behaviours), social (i.e. friends and family), physical (i.e. home, school and supermarkets) and the macro-level environment (i.e. industry, government policy, food marketing and media).³⁸ This framework helps us to appreciate the complexity and reality that there is no one easy solution (see Figure 1).

While it is recognised that what children eat at home is important³⁹ a current focus is on the school environment and the food served at school. The use of the school environment is supported by evidence from systematic reviews that found implementing dietary interventions in schools can have a positive impact

on improving children's diets.^{40, 41} The role of schools in addressing children's diet and obesity has also been advocated in a number of government reports (see Table 3). Collectively, what the reports highlight is that the school environment can potentially span the individual, social, physical and macro-levels identified in the ecological framework by Story *et al*, 2008³⁸ (see Figure 1). However, it is important to acknowledge that the school environment, with specific reference to the food served at school, can only influence the diets of children who eat food served at school i.e. breakfast and afterschool clubs, break-time or lunchtime (school lunch).^{39, 42}

Table 3 Government reports and the role of schools in improving children's diets

Report	Brief aim	Role of school
Choosing Health: making healthier choices easier (2004) ¹¹	Addresses issue of unhealthy foods and diets	➤ Improve nutrition in schools
Choosing a Better Diet: a food and action plan (2005) ¹²	Reduce obesity, improve diet and inequalities by decreasing fat, saturated fat, salt, sugar and increase fruit and vegetables	➤ Include nutrition in curriculum, concept of a balanced diet and the benefits of healthier lifestyle ➤ Improve nutrition
PSA Delivery Agreement 12: improve the health and wellbeing of children and young people (2007) ⁴³	Priority to reduce overweight and obesity	➤ Improve quality of school lunch ➤ Increase take-up ➤ Reduce childhood obesity: provide an environment to support healthy food and activity choices
Foresight: tackling obesity-future choices (2007) ²	Multi-factorial approach required to deal with complexity of obesity	➤ Provide healthy school meals
Healthy weight, healthy lives: a cross government strategy for England (2008) ⁴⁴	Support individuals to make healthier choices to reduce obesity levels, especially in children	➤ Focus on school environment: i.e. is school canteen conducive to healthy eating? Length of time queuing, ➤ Consider on-site policies ➤ Whole-school approach i.e. 'healthy schools' ➤ Develop healthy lunch box policies
Food matters: towards a strategy for the 21st century (2008) ⁴⁵	Recognises food overlaps with many aspects of food policy	➤ Ban vending machines ➤ Decrease foods high in salt and added sugar

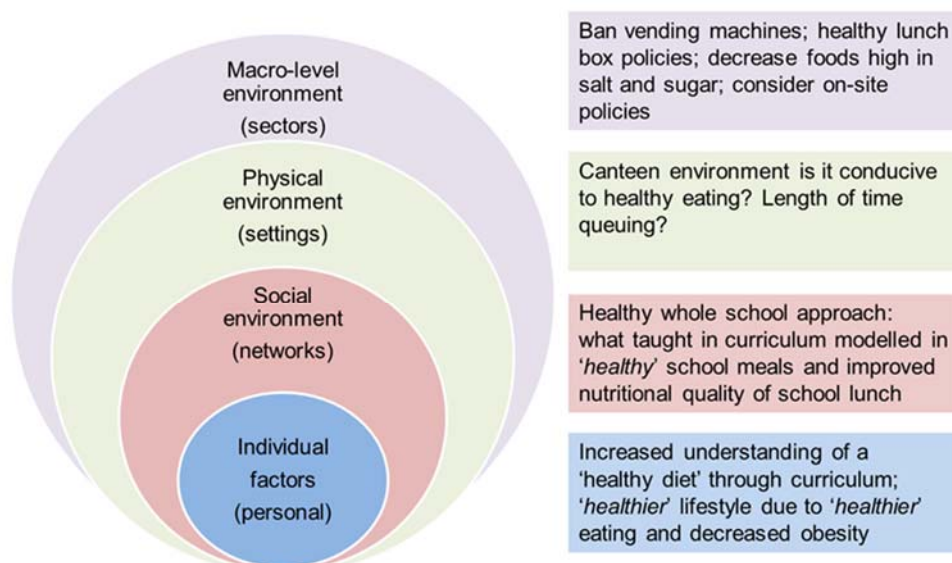


Figure 1 An adaptation of the ecological framework and the role of schools at the individual, social, physical and macro-levels as identified in government reports (2004-2008)

As indicated in Figure 1 there are a number of environmental and individual level factors that influence what children eat. Papers II-IV evaluate the impact of implementing the food and nutrient-based standards to school lunch in England on children's diets. The key focus is on the macro-level environment. The papers consider the findings and if legislation to school lunch is in itself sufficient, or, if this needs to be supported by other levels (i.e. the physical environment) to improve children's diets. This is also discussed in Chapter 6.

During my PhD studies I co-authored a report for the Department of Health (Public Health Research Consortium)⁴² and a paper published in Public Health Nutrition entitled School food standards in the UK: implementation and evaluation.⁴⁶ Both publications include a short historical outline of the school meal policy in England. Papers II-IV^{39, 47, 48} also make a brief reference to the historical context. In order to set Papers II-IV in their wider policy context leading to implementation of the food and nutrient-based standards to school lunch in England, a more detailed historical outline is presented below (see also Table 4).

2.4 Policy context: The history of school meals in England [1900-2014]

2.4.1 1906: Introduction of school meals

School meals were first introduced as a response to under-nutrition of children and the subsequent poor health of potential army recruits for the Boer war (1899-1902).⁴⁹ The publication of the Inter-Departmental Committee on Physical Deterioration in 1904 highlighted the public health concern of undernutrition and a key recommendation was free school meals should be introduced for children from poorer families.⁴⁹ In 1906 the Education (Provision of Meals) Act required that children receive adequate food in school; Local Education Authorities (LEAs) could provide free meals, but this was not a requirement.⁵⁰ There was some opposition that school meals should be available for all children; therefore, free school meals were only provided to children who were undernourished (assessed by a medical inspection) and poor (assessed by the parent's financial situation).⁵¹ This highlighted the belief that school meals were linked to poverty and should not be taken, even if children were eligible for them.⁵²

In some LEAs the quality of school meals and the environment for eating a school meal were inadequate. In contrast, some LEAs tried to demonstrate that school meals were an opportunity for developing social skills and 'healthier' eating habits.⁵² However, challenges persisted. While it was recognised that adequate supervision, sufficient time to eat and the environment were important,⁵² these factors were not addressed. A quote from Hall, 1952 summarises the conditions:

'Too often the premises are makeshift and over-crowded, the supervisors harassed, the meal bolted and the children hurried out to make room for a second batch' (Hall, 1952 p171).⁵²

2.4.2 1941: Nutrient standards established

The first nutrient-based standards for school meals were introduced in 1941 with recommendations for energy, fat and protein. The 1944 Education Act led to a legal requirement for LEAs to provide free school meals to any child who wanted them.⁵³ This provision of free school meals ended in 1950 when a

standard charge was introduced. The nutritional standards for school meals were reviewed on three occasions: 1955, 1965 and 1975.⁴⁹

2.4.3 1980: Nutrient standards removed

Having addressed the nutritional quality of school meals by imposing standards in 1941, the 1980 Education Act⁵⁴ removed all nutritional standards. This action was taken despite the Black Report (1980) which highlighted that nutritious school meals were an important aspect of child health.^{53 55} There were a number of other developments during the 1980's that had a negative impact on school meals. LEAs were no longer required to provide school meals, except to children eligible to free school meals.⁵³ Free school meal entitlement for children living in families in receipt of family credit was removed, and in 1988, the Local Government Act introduced compulsory competitive tendering (CCT).⁴⁹ The 1980 Act also obliged LEAs to offer contracts to those companies offering the cheapest service for school meals.⁵³ In essence, the provision of school meals was influenced by financial considerations, as opposed to nutritional quality.⁵³ This was also a period where the school meal service in secondary schools became more like a canteen and children could pay for the foods they selected.⁵⁶

2.4.4 2001: Introduction of food-based standards

Following the abolition of nutrient requirements for school meals in 1980, the School Meal Campaign of the Caroline Walker Trust (1992)⁴⁹ recommended nutritional standards should be reintroduced. Recommendations were published but these were ignored. In 1997, the White Paper Excellence in Schools⁵⁷ noted that nutritional standards for school lunch should be re-introduced. However, it was not until 2001, over twenty years after the removal of nutritional standards that food-based standards for school lunches were reintroduced. These standards imposed on caterers the need to provide 'healthy' options in school lunch. Although they specified the types of foods and frequency of serving they did not limit food choice.⁵⁸ Furthermore, they did not include nutrient-based recommendations. Thus, there were no guidelines for the percentage of energy from fat, saturated fat, non-milk extrinsic sugars or the micronutrient content a school lunch should provide.

In 2004⁵⁹ and 2006,⁶⁰ two reports showed that despite the implementation of food-based standards in 2001 school lunches remained high in fat, sugar, and salt, and low in micronutrients.^{59, 60} Although ‘healthy’ choices may have been available, children were not choosing to eat these foods. Findings also reported that between a quarter and a third of energy and nutrients eaten by a child were provided by school meals,⁵⁹⁻⁶¹ emphasising the importance of school meals on children’s diets.

2.4.5 2006: Implementation of food and nutrient-based standards

In 2005, there were three key developments that were influential in transforming school food. The media broadcast of Jamie Oliver’s ‘Jamie’s School Dinners’ that received attention from the public (in particular parents) and Government (February);^{62, 63} the School Meal Review Panel (SMRP) formed to provide advice on school lunch standards (March);⁵⁸ and the establishment of the School Food Trust to ‘*transform school food*’ (April).⁶⁴

The SMRP reported the deterioration in school meals was due to economic constraints, the removal of nutritional standards and a long period of neglect of school food.⁵⁸ In 2006, 100 years after the first provision of school meals, there was a significant change in policy with the implementation of food and nutrient-based standards in England. The implementation of these standards received legislative support.^{13, 39}

Considerable economic investment was required to implement this legislation. The School Food Trust (now Children’s Food Trust) received £38 million from Government over a six year period, and a further £480 million was provided to schools to subsidise cost of ingredients, equipment (such as software for analysing menus) and professional support.⁶⁵ In 2006, the new food and nutrient-based standards were introduced. Primary schools were expected to comply by September 2008 and secondary schools by September 2009.⁶⁶ Food-based standards specified which foods could, and perhaps more importantly, which foods could not be served. They also specified how often some foods (i.e. deep fried foods such as chips) should be served over a three-week period. Food-based standards apply to the whole school day including breakfast clubs.⁶⁴ Nutrient-based standards apply to the average nutritional content of school lunches over a (typically) three-week menu cycle and specify

minimum and maximum levels.⁶⁴ The food and nutrient-based standards apply to planned provision rather than children's actual food or nutrient consumption.

School food has received considerable attention and economic investment in England over the last few years. The aim is to improve what children eat by limiting the availability of certain foods (e.g. fried chips) and increasing the availability of other foods (e.g. fruit and vegetables). Chapter 3 provides a narrative review of the current literature; it examines the impact of the implementation of food and nutrient-based standards on children's diets at lunchtime, and/or in their total diet.

Table 4 Historical events in school meals in England from 1900 to 2014 with key reports and national surveys

	Year	Events	Reports	National surveys
School meals introduced	1904	School meals provided under the auspices of charities	Inter-departmental committee on physical deterioration	
	1905		Inter-departmental committee on medical inspection and feeding of children attending public elementary schools	
	1906	Education Act: provision of free school meals; though not compulsory ⁵⁰		
Nutrient standards established	1941	First nutritional standards: energy, fat and protein ⁴⁹		
	1944	Education Act: legal requirement for Local Education Authority (LEA's) to provide school meals		
	1955	Working party on nutritional aspects of school meals: nutritional standards reviewed (1955, 1965 & 1975) ⁴⁹		

Table 4 Historical events in school meals in England from 1900 to 2014 with key reports and national surveys continued


		Year	Events	Reports	National surveys
	Nutrient standards removed	1980	Education Act: removal of all nutritional standards ⁵⁴	The Black Report ⁵⁵	
			LEA's no longer required to provide school meals except for those entitled to free school meals		
			Removal of entitlement to free school meals for children living in families in receipt of family credit		
		1988	Introduction of Compulsory Competitive Tendering		
		1989			Diets of British School Children ⁵
Implementation of the 'school food policy'	1991		The Health of the Nation - a strategy for Health in England ⁶⁷		
			Department of Health published energy and nutrient recommendations for the UK ²¹		
		1992	Caroline Walker Trust: nutrient-based standards		

Table 4 Historical events in school meals in England from 1900 to 2014 with key reports and national surveys continued



		Year	Events	Reports	National surveys	
	Implementation of the 'school food policy'	1994		Eat Well - action plan from the Nutrition Task Force to achieve the Health of the Nation targets on diet and nutrition		
		1999		Saving Lives: Our Healthier Nation ⁶⁸		
		2000	Academies first established under the labour government		National Diet and Nutrition Survey 4-18y olds ⁶	
		2001	National nutritional standards			
		2004		Choosing health - making healthy choices easier ¹¹	School meals in secondary schools, England ⁵⁹	
		2005	February: Jamie Oliver's media broadcast 'Jamie's School Dinners'	Choosing a better diet - a food and health action plan ¹²		
			March: School meal review panel established			
			April: School Food Trust established to transform school food			
2006	Interim-based standards		School meals in primary schools, England ⁶⁰			

Table 4 Historical events in school meals in England from 1900 to 2014 with key reports and national surveys continued

	Year	Events	Reports	National surveys	
	Implementation of the 'school food policy'	2007	PSA Delivery Agreement 12 - Improve the health and wellbeing of children and young people ⁴³	Low income diet and nutrition survey	
			Foresight - Tackling Obesities - Future Choices ²		
		2008	September: primary schools to be fully compliant with food & nutrient-based standards	Healthy weight, healthy lives - a cross government strategy for England ⁴⁴ Food matters - towards a strategy for the 21 st century ⁴⁵	National child measurement programme 2006-07 (annual report) ⁶⁹
	2009	September: secondary schools to be fully compliant with food & nutrient-based standards			
	Introduction of universal free school meals key stage 1	2011		Healthy lives, healthy people: update and way forward ⁷⁰	
		2012	Expert panel for the school food plan established		National Diet and Nutrition Survey results from years 1, 2 and 3 combined ⁸
2013			The school food plan		
2014		September: Free school meals for all children in Key Stage 1 (<i>referred to in discussion</i>)			

Chapter 3 Literature review

Chapter overview:

The aim of this chapter is to provide a narrative review of the literature examining the impact of a child's lunch type (school or home-packed lunch) on their dietary intake at:

- lunchtime
- in their total diet and
- across the socio-economic spectrum

A brief background is given, followed by the objective and methods used. To conclude, a summary of the main points, the rationale and key research questions are stated.

3.1 Background

As discussed in Chapter 2 the school food environment, in particular what children eat at school, has gained increased attention. The implementation of the food and nutrient-based standards to school lunch has been a major policy change to school food in England. However, changes to school lunch are not limited to England; school lunch is also a focus internationally. This chapter provides a narrative review of the current literature and highlights research questions that remain unanswered.

3.2 Objective

The objective of this narrative review is to explore the impact of a school lunch, home-packed lunch, or, the comparison of a school/home-packed lunch on children's dietary intake at: (i) lunchtime or (ii) in their total diet.

3.3 Search strategy

To ensure my search strategy was comprehensive and methodical a systematic approach was undertaken to this (see sections 3.3.1 and 3.3.2) narrative review of the current literature. The systematic approach for the search strategy is a strength. A key limitation is that there was only one reviewer, therefore there is potential for selection bias in the papers reported. This narrative review enables key study findings to be reported and discussed, and for gaps in the literature to be noted. This approach does not allow for an in-depth analysis of the findings as in a systematic review or meta-analysis.⁷¹

3.3.1 Criteria for considering studies in this review

Types of studies

All study designs were eligible for inclusion. Studies needed to be written in English, but were not excluded based on geographical location. For studies reporting on school lunch they needed to examine the impact of a school food policy change as opposed to individual school level dietary interventions. For example, studies that looked at individual school interventions to increase fruit and vegetable intake were excluded. Studies needed to examine children's consumption of food or nutrients. Studies were excluded if they reported findings based only on planned provision of food offered.

Types of participants

Children who attended primary, middle or secondary schools were included. Studies with a focus on children attending nurseries were excluded.

Settings

Primary, middle, secondary schools and home.

Types of outcome measures

Studies had to report on one or more of the following primary review outcomes on children's dietary intake to be included.

Primary outcomes

The primary outcomes of interest were children's:

- i. mean nutrient intake
- ii. mean food and drink intake, or a
- iii. comparison of children's dietary intake against food and/or nutrient-based standards

Secondary outcome

The secondary outcome of interest was whether studies reported any effect across the socio-economic spectrum in the primary outcomes listed above.

3.3.2 Search methods for identifying studies

The following three commonly used electronic databases were searched: MEDLINE, EMBASE and PsycINFO. Table 5 shows the complete search strategies and search dates for each database, along with the terms and searches conducted. On initial screening of the papers duplicated studies were removed and titles were screened for eligibility. If it was not possible to make a decision based on the title then the abstract was read. Figure 2 is based on the Preferred Reporting Items for Systematic Reviews (PRISMA)⁷² template and is included to give an overview of the total number of studies identified, excluded and included. As noted in section 3.3 screening of studies was carried out by one reviewer, therefore the detailed guidelines applied in a systematic review were not undertaken.

Table 5 Databases, terms used and searches conducted for literature review

Database resources searched	
1	Ovid MEDLINE (R) In-Process & other Non-Indexed Citations and Ovid MEDLINE (R) 1946 to present
2	Embase 1980 to 2014 week 18
3	PsycINFO 1967 to May Week 1 2014
Terms used	
1	(school lunch* or school meal* or school food* or hot school meal* or hot school lunch*).mp
2	(home-packed lunch* or home lunch* or packed lunch* or bagged lunch*).mp
3	(standards for school lunch* or policy* or nutrient-based standards* or food policy* or school food policy* or nutritional requirements* or menu planning* or menu standards*).mp
4	(diet* or nutrition* or nutritive value*).mp
5	(lunch* or meal at lunch* or midday meal*).mp
6	(school* or primary school* or secondary school*).mp
7	(socio-economic inequality* or poverty or socio-economic spectrum* or socio-economic disparities or social class* or socio-economic factor* or index of multiple deprivation*).mp
Searches conducted	
1	1 and 3 and 4
2	1 and 3 and 7
3	1 and 3 and 8
4	1 and 2 and 3 and 4
5	2 and 3 and 4
7	1 and 2 and 3 and 4 and 7
9	4 and 5 and 6

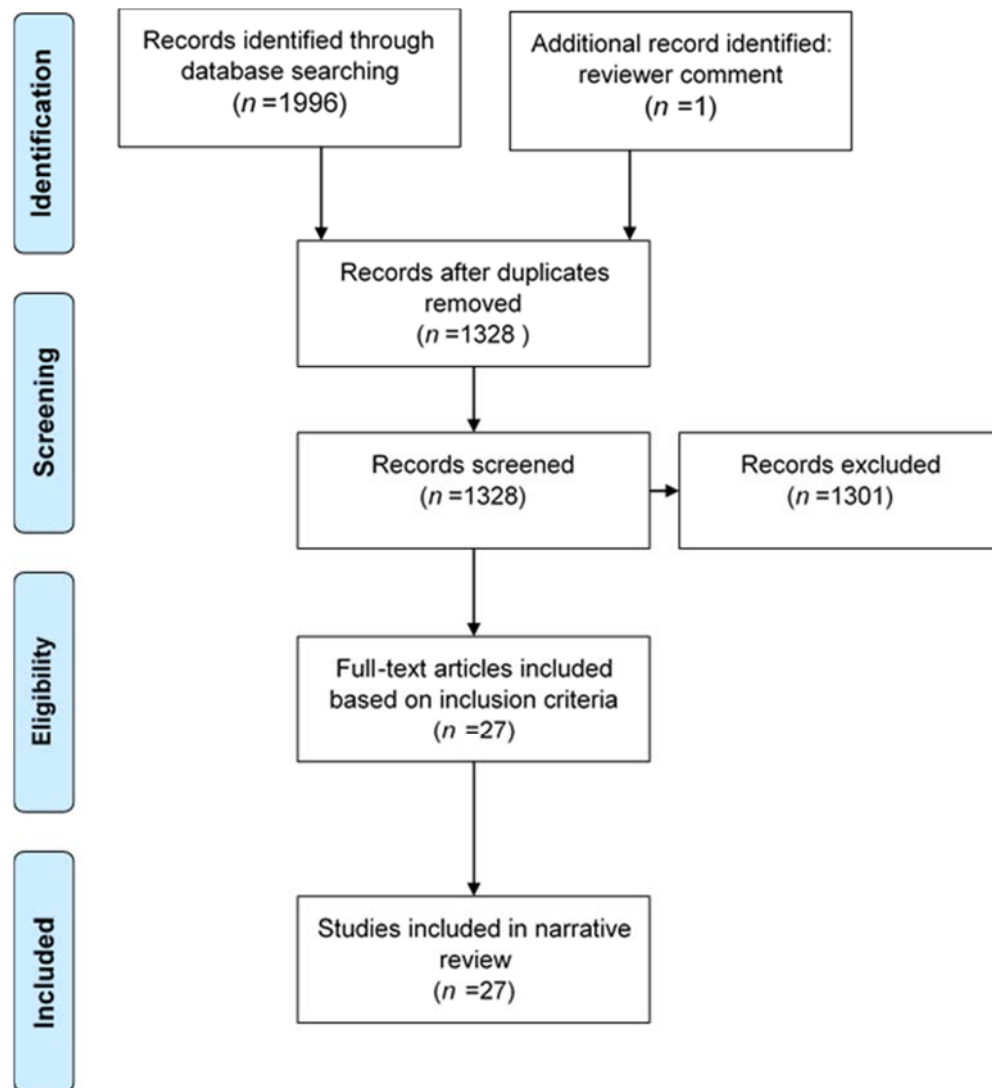


Figure 2 Total studies identified and number included in the literature review based on PRISMA guidelines

Data collation

The data collated from the included studies describes study authors and date, geographical location, school (i.e. primary or secondary), children's age and number of participants. It also includes the study aim, design and method, whether the data used in the studies were pre or post-policy implementation and a summary of key findings. Two steps were employed to organise and discuss studies. Firstly, studies were separated into two main categories: those that examined children's dietary intake at lunchtime, and in their total diet. Secondly, studies were categorised by lunch type: school lunch, home-packed lunch and a comparison of school/home-packed lunch.

3.4 Review of included studies

Each section below begins with a general description of the identified studies ($n=27$) and is structured to provide an overview of the number of studies included, the geographical location, the study design, the children's age and the dietary data collection methods used. Where applicable, a summary of the main study characteristics and findings are provided in Tables (Table 6, Table 7, Table 8 and Table 11). The main findings are discussed under the pre-defined outcomes: nutrient intake, food and drink intake or a comparison of nutrient/food intake consumed against the food and nutrient-based standards, and socio-economic effects. The studies included are from different geographical locations therefore the policies effect on school lunch^a described vary. Some examples are given of the policies, but this list is not exhaustive. The studies of school lunch based in the UK (England) can be expected to comply with food and nutrient-based standards.⁶⁴ These specify what foods can and cannot be served, and minimum and maximum levels of nutrients. In the USA there are state policies that limit portion size and fat content of high-fat/sugar foods and drinks.⁷³ In other countries, such as Belgium the school food policy is less proscriptive.⁷⁴ Comparability of school food policies in different countries is referenced to in Chapter 6.

3.4.1 Lunchtime: children's mean dietary intake

3.4.1.1 School lunch

Description of studies

Eight studies were identified: one from Belgium, five from the UK and two from the USA (Table 6). Seven studies were cross-sectional and one was a cluster randomised study. Children's ages ranged from 3y to 19y. Three studies were carried out in primary schools, three in secondary schools and two included both primary and secondary schools. Various dietary data collection methods were used which included: questionnaires, weighed, observational and photographs. See Table 6 for a summary of key study characteristics and findings.

^a In this section the following terms: recommendations, food and nutrient-based standards, standards, pre-policy & post-policy implementation are used to refer to a 'school food policy'

Nutrient intake

Three studies⁷⁵⁻⁷⁷ examined children's nutrient intake at one time point only: pre-policy implementation. A summary of their findings is shown in Table 6. Two studies^{78, 79} examined the change in children's nutrient intake pre to post-implementation of the food and nutrient-based standards in England. Both studies found a decrease in children's mean consumption of: energy, per cent energy from fat, saturated fat, NMEs and absolute amounts of fat, saturated fat. They also reported an increase in mean protein, NSP and vitamin A intakes. There were inconsistencies reported in mean intakes of calcium, zinc and vitamin C. For example, Haroun *et al*, 2010⁷⁸ found mean intakes of calcium increased in the infants but decreased in the juniors. Nicholas *et al*, 2013⁷⁹ found calcium increased. The study by Mendoza *et al*, 2010⁷³ that examined the impact of a school food policy pre to post-policy implementation in the USA is discussed in 'socio-economic effects' section.

Food and drink intake

In 2005, Vereecken *et al*,⁷⁴ examined the availability of food at lunch time in 197 schools (primary $n=64$; secondary $n=183$). A small proportion of primary schools (9%) had vending machines compared with 80% of the secondary schools. In addition, approximately half of secondary schools had no written policy on biscuits, sweets and savoury snacks. In comparison, very few primary schools had no policies on these foods (11%, 3% and 10% respectively). In the secondary schools, the school a child attended and the food available was associated with consumption of soft drinks, sweets and crisps ($p<0.01$).⁷⁴ For example, if soft drinks were available at school then children were more likely to consume them.

A study by Nelson *et al*, 2007⁶¹ reported that children's food choices had deteriorated in 2004 (secondary schools) and in 2005 (primary schools) compared with 1997. For example, in 2004 in secondary schools, children reported a higher consumption of chips, soft drinks, desserts, cakes and biscuits than in 1997. They also reported a lower consumption of fruit and vegetables. In 2005, in primary schools children also reported a higher consumption of chips and desserts, cakes and biscuits, but also more vegetables. Post-policy implementation in England findings by Haroun *et al*,

2010⁷⁸ and Nicholas *et al*, 2013⁷⁹ found a different scenario. Haroun *et al*, 2010⁷⁸ assessed both food and drink provision, and consumption in 136 primary schools. They compared intake in 2005 with 2009. By 2009, schools had improved food and drink provision. Schools provided more: vegetables and fruit ($p < 0.001$ for both), fruit juice and fruit-based desserts ($p < 0.001$) and starchy foods not cooked in fat ($p = 0.004$). Schools provided fewer: desserts not containing fruit ($p < 0.001$), savoury snacks and confectionery ($p < 0.001$). Nicholas *et al*, 2013⁷⁹ also reported similar findings.

Comparison of children's mean dietary intake against nutritional recommendations for school lunch

Six of the studies compared children's nutrient intakes against standards; four^{61, 75-77} examined this pre-policy and two post-policy implementation.^{78, 79} Pre-policy Gould *et al*, 2006⁷⁵ found fat and saturated fat intakes were above recommendations; no child met the recommendation for iron and folate and less than 10% met the calcium recommendation. Nelson *et al*, 2007⁶¹ reported children's mean intake of NSP, iron, zinc and vitamin A were below the recommendations. The finding that children's intakes did not meet recommendations was further supported by Gatenby *et al*, 2007.⁷⁶ Post-policy, despite implementation of standards, children's intakes did not meet *all* the standards. For example, children's mean intakes of iron and zinc were least likely to meet the standards. In contrast, children's mean intakes of fat, saturated fat and NMES met the standards.^{78, 79} These findings imply children's micronutrient intakes are less likely to meet the recommendations as opposed to macronutrient intakes. Potential reasons for this may be the standards apply to food provision as opposed to what children actually consume. Comparison of children's intakes against the standards that does not cover the three-week menu cycle (that nutrients are required to comply to) may be limited to adequately assess micronutrient intakes. Furthermore, the standards have restricted the provision of certain foods such as deep fried foods and sweets/confectionery; these restrictions may be more effective in influencing children's intakes. In comparison, addressing children's micronutrient intakes (i.e. iron and zinc) may be more difficult as foods containing these nutrients, such as dark green vegetables, pulses and beans, and nuts are foods that children need to choose to eat.

Socio-economic effects

A study by Mendoza *et al*, 2010⁷³ examined the impact of the Texas Public School Nutrition Policy across the socio-economic spectrum in three schools. This policy restricts portion sizes of snacks high in fat and sugars, and the fat content of foods. Socio-economic status (SES) was determined by a school-level measure: that is the number of children registered in the federal/free reduced lunch programme. They examined the impact pre to post-policy implementation on energy density. They found energy density had improved (decreased) across all three schools; the greatest effect was for children in the schools classified as 'less deprived'. Pre-policy implementation these schools were found to have the highest energy density compared to the 'more deprived' schools. As noted by Mendoza *et al*,⁷³ this may be because children had more money to spend on snack foods and foods from the vending machines in the 'less deprived' schools.⁷³ Post-policy implementation the availability of these items was restricted. Therefore, children could not purchase items such as crisps.

Limitations

There are a number of limitations with these studies that examined the impact of school food policies on children's dietary intake at lunchtime. To start, a small number of studies ($n=3$) reported the impact of school food policies on children's dietary intake pre to post-policy implementation. Therefore, the majority of studies do not evaluate the impact of implementing the school food policy pre and post-policy. The findings by Mendoza *et al*, 2010⁷³ are limited to energy density and the study does not report micronutrients. In comparison, other studies reported a number of nutrients related to the implementation of nutrient-based standards.⁷⁷⁻⁷⁹ The studies were conducted in various geographical locations, therefore, school food policies and the findings reported varied.

The studies also used various dietary collection methods. There are a number of issues in the dietary data collection methods that potentially limit the dietary data quality collection. A number of studies used a self-report dietary data collection method.^{73, 74} One study used different dietary data collection methods in the two surveys reported; in the first survey dietary data were collected

retrospectively, and in the second it was observed.⁶¹ In two studies^{78, 79} a 5d weighed intake was reported but this was not for each child; rather it was for different children randomly selected on the days of dietary data collection. A further limitation was that the weighed intake method required weighing the foods on offer at the counter; each food was then allocated an average portion weight. Food weight eaten was estimated by subtracting the leftover weight from the average portion weight. Children who did not take their leftovers to be weighed were considered to have consumed all foods.^{74, 75}

A number of studies reported children's mean intake against nutritional recommendations for school lunch. However, the dietary data collection period did not cover the three week menu cycle that the food and nutrient-based standards cover.^{78, 79} Furthermore, Martin *et al*, 2010⁷⁷ noted that the evaluation was undertaken soon after the recommendations were introduced and schools may not have fully implemented them.

In the study by Mendoza *et al*, 2010⁷³ which examined the impact of school food policy across socio-economic status, SES was analysed at the school and not individual level. They noted that a change in school demographics between the two time points may be have been associated with the changes found.⁷³

Questions that remain unanswered

These studies only focus on school lunch. As noted in the limitations only three studies have examined the change from pre to post-policy implementation. The question of whether there is a widening difference in school and home-packed lunches since the introduction of policies specific to school lunch remains.

In addition, these studies examined the impact of implementing school food policies on children's diets at lunchtime only. Therefore, the potential wider impact on children's total diet is not known. For example, it may be that children from the less deprived schools eat 'healthier' at school due to restrictions, but purchase restricted items more frequently outside of school.⁷³ This emphasises the importance of considering the impact of implementing school food policies on children's diets outside of the school environment.

Table 6 Characteristics of included studies examining school lunches (lunchtime)

Study characteristics: school lunches								
Study	Country	School (n)	Children (n)	Age/school grade	Aim	Design & method	Data used	Key findings
Vereecken <i>et al</i> 2005 ⁷⁴	Belgium-Flanders	Primary (64) Secondary (110)	16560	11-18y	Examine the influence of a school food policy on consumption of soft drinks, sweets and crisps	<ul style="list-style-type: none"> ➤ Cross-sectional ➤ Frequency questionnaire examining key variables: soft drink, sweets/ chocolate and crisps 	Health Behaviour in School aged children survey	<ul style="list-style-type: none"> ➤ Factors affecting children's soft drink consumption: availability (p<0.001), no policy (p<0.01) and school from lower SES (p<0.001) ➤ Sweets: lower SES (p<0.01) ➤ Crisps: no policy (p<0.01) & lower SES (p<0.001)
Gould <i>et al</i> 2006 ⁷⁵	UK (England)	Secondary (3)	74	11-12y	Examine if food meets standards Examine food choice on nutrient intake	<ul style="list-style-type: none"> ➤ Cross-sectional ➤ 5d indirect weighing method 	Pre-policy	<ul style="list-style-type: none"> ➤ 2 out of 3 schools did not meet standards ➤ Children from lower SES had less nutrients ➤ 75% of children >35% per cent energy from fat ➤ No child met iron or folate recommendations
Gatenby <i>et al</i> 2007 ⁷⁶	UK (England)	Primary (2)	64	9-10y	Assess nutritional content of meals and children's actual intake	<ul style="list-style-type: none"> ➤ Cross-sectional ➤ 5d weighed/ photographed meals before & after eating 	Pre-policy	<ul style="list-style-type: none"> ➤ Fat, sugar and sodium exceeded Caroline Walker Trust guidelines ➤ Children's intakes did not meet recommended guidelines for 11 of 17 nutrients assessed

Table 6 continued								
Study characteristics: school lunches								
Study	Country	School (n)	Children (n)	Age/school grade	Aim	Design & method	Data used	Key findings
Nelson <i>et al</i> 2007 ⁶¹	UK	Primary Secondary	1456	4-18y	Examine contribution to mean daily food and nutrient intake Compare 1997 data with 2004-5	<ul style="list-style-type: none"> ➤ Cross-sectional secondary analysis from 1997 NDNS 7d weighed ➤ Parents may have completed dietary intake at lunchtime retrospectively; in 2004 and 2005 observed 	Pre-policy	<ul style="list-style-type: none"> ➤ In both primary and secondary schools school lunches did not meet CWT guidelines for most nutrients aside from protein and vitamin C
Haroun <i>et al</i> 2010 ⁷⁸	UK (England)	Primary (136)	6696	3-12y	Examine lunchtime provision of food and drink Examine food/drink choices and consumption	<ul style="list-style-type: none"> ➤ Cross-sectional ➤ 1-5d observation and leftovers weighed 	Pre & post-policy	<ul style="list-style-type: none"> ➤ Post-policy schools provided more vegetables and salad and fruit juice ➤ Less condiments and confectionery (p<0.001), starchy food cooked in fat (p=0.004) ➤ Post-policy consumption of NMES, fat, saturated fat and sodium was lower;
Martin <i>et al</i> 2010 ⁷⁷	USA	Primary (33)	2049	9-12y (Grades 4-6)	Examine food selection, plate waste and food intake against standards	<ul style="list-style-type: none"> ➤ A cluster randomized study ➤ 3d photograph measuring food selection, plate waste and food intake 	Students enrolled in the Louisiana Health study	<ul style="list-style-type: none"> ➤ Most children met protein, iron, calcium and vitamin A recommendations but not vitamin C ➤ Saturated fat intakes exceed recommendation

Table 6 continued Study characteristics: school lunches								
Study	Country	School (n)	Children (n)	Age/school grade	Aim	Design & method	Data used	Key findings
Mendoza <i>et al</i> 2010 ⁷³	USA	Middle (3)	Lunch records (n of children not reported)	11-14y (Grades 6-8)	Assess the impact of the Texas Public Nutrition School policy on children's energy density	<ul style="list-style-type: none"> ➤ Cross-sectional ➤ Self-completed food record post-lunch 	Pre and post-policy	<ul style="list-style-type: none"> ➤ Energy density decreased significantly (foods only $p < 0.0001$; food and beverages $p < 0.0001$)
Nicholas <i>et al</i> 2013 ⁷⁹	UK (England)	Secondary (80)	5969	10-19y	<p>Assess lunchtime provision, choices and consumption of food and drink</p> <p>Compare pre and post standards</p>	<ul style="list-style-type: none"> ➤ Cross-sectional ➤ Foods items on offer and no. of portions/weights recorded ➤ Lunch weighed before and after eating 	Pre and post-policy	<ul style="list-style-type: none"> ➤ Post-policy more schools provided vegetables and salads, water, fruit juice ($p < 0.005$) for all ➤ Post-policy children's consumption of NMES, fat, saturated fat and sodium decreased; per cent energy from NMES, fat and saturated fat also decreased

3.4.1.2 Home-packed lunch

Description of studies

Three studies examined what children consume in their home-packed lunches: one from New Zealand⁸⁰, one from the USA⁸¹ and one from England.⁸² All of the studies used a cross-sectional design. Children's ages ranged from 5y to 11y. Two studies were carried out in primary schools,^{80, 82} and one in a middle school.⁸¹ Various dietary data collection methods were used which included: observational, photographs and a weighed intake. A summary of the key study characteristics and findings is shown in Table 7.

Nutrient intake

Two of the studies^{81, 82} presented information on children's mean nutrient intakes. Conway *et al*, 2002⁸¹ presented findings by gender and grade on four nutrients: mean energy, total fat, saturated fat and sugars. They found that boys home-packed lunches contained more fat than girls ($p < 0.001$). Home-packed lunches contained more sugar in the older boys (grade 8) compared with the younger boys (grades 6 and 7), and boys intake of sugar was higher compared to girls (gender by grade interaction $p < 0.04$). Evans *et al*, 2010⁸² also presented findings on nutrients ($n=14$) which included: mean energy, fat, saturated fat and sugars defined as NMES. They did not find a difference by gender.

Food and drink intake

A consistent finding in these studies was that the most common foods in the average home-packed lunch were: sandwiches, savoury snacks or crisps, biscuits or a cookie and a drink across the three countries.⁸⁰⁻⁸² Fruit was more commonly consumed than vegetables.^{81,82}

Comparison of children's mean dietary intake against nutritional recommendations for school lunch

The study by Evans *et al*, 2010⁸² examined the nutritional content of home-packed lunches against the food and nutrient-based standards for school lunch in England. Although these standards do not apply to home-packed lunches they found less than 2% of home-packed lunches met *all* the recommendations

for school lunches in England. Few home-packed lunches met the nutrient-based standards for NMES (18.5%), sodium (19.4%), iron (24.8%) and zinc (27.9%).⁸²

Socio-economic effects

One study by Dresler-Hawke *et al*, 2009⁸⁰ found no difference in fruit and vegetables provided in lunches or sodium intake across the socio-economic spectrum. However, they found children who attended schools in more deprived areas had higher fat ($p<0.05$) and sugar ($p<0.01$) contents in their home-packed lunches. Evans *et al*, 2010⁸² did not find a difference.

Limitations

A key limitation with the studies examining home-packed lunches is that no baseline data were reported. This limits the ability to determine if home-packed lunches have become more 'healthy' or less 'healthy' over time.

There are also some limitations in the methods used. Conway *et al*, 2002⁸¹ report they observed home-packed lunches, but it is not made clear if they observed and recorded children's actual intake. From the methods described it would appear they report the contents rather than actual consumption. Dresler-Hawke *et al*, 2009⁸⁰ used a photograph method. Children's lunch boxes were photographed at the start of the day. To determine the food children consumed at lunch time they measured total waste disposal contents. Therefore, this method does not account for individual child variation.

In both studies that examined the SES effect individual child level demographics were not used; school level classification of SES was used. Evans *et al*, 2010⁸² used the % Free School Meal Entitlement; Dresler-Hawke *et al*, 2009⁸⁰ selected schools based on school level of deprivation. The different dietary data collection methods and SES classification may account for the discrepancies in studies nutrient and SES findings. Furthermore, dietary data was only collected on one day. Therefore day to day variation in children's dietary intake is not accounted for.

Questions that remain unanswered

By examining home-packed lunches only at one point in time the question of whether they have improved remains. In addition, whether they are on average more 'healthy' or less 'healthy' compared with a school lunch is unanswered by these studies.

Table 7 Characteristics of included studies examining home-packed lunches (lunchtime)

Study characteristics: home-packed lunches								
Study	Country	School (n)	Children (n)	Age/school grade	Aim	Design & method	Data used	Key findings
Conway <i>et al</i> 2002 ⁸¹	USA	Middle (24)	1381	11-14y (Grades 6-8)	Examine different food types	<ul style="list-style-type: none"> ➤ Cross-sectional ➤ Observational 	Not applicable	<ul style="list-style-type: none"> ➤ Common foods: beverages (75%) and sandwiches (70.8%) ➤ Fruit more common than vegetables (47% and 6% respectively) ➤ Savoury snacks more common than biscuits, sweets and cakes/pies
Dresler-Hawke <i>et al</i> 2009 ⁸⁰	New Zealand	Primary (6)	927	5-11y	Determine food contents	<ul style="list-style-type: none"> ➤ Cross-sectional ➤ 1d photograph of lunches box and waste disposal contents 	Not applicable	<ul style="list-style-type: none"> ➤ 70% contained fruit and vegetables; 32.4% met the standard of 2 servings ➤ Cakes muffins and biscuits (44%); crisps (57%); confectionery (15%) ➤ SES: no difference in fruit & vegetables or sodium ($p>0.05$); lower SES lunches had more fat ($p<0.05$) and sugar ($p<0.01$)
Evans <i>et al</i> 2010 ⁸²	UK (England, Wales, Scotland & N.Ireland)	Primary (89) England (76) Wales (6) Scotland (4) N.Ireland (3)	1294	8-9y	Compare against food and nutrient-based standards	<ul style="list-style-type: none"> ➤ Cross-sectional ➤ 1d food weighed before and after 	Not applicable	<ul style="list-style-type: none"> ➤ 1.1% met <i>all</i> standards for school lunches ➤ Nutrients most likely to be met: carbohydrate, protein and vitamin C; least likely to be met: energy, NMES and sodium ➤ 18% had no confectionery/savoury snacks; 40% had both

3.4.1.3 School and home-packed lunch

Description of studies

Ten studies examined what children consumed in both school and home-packed lunches: one study was based in Canada, one in the USA and eight in England (see Table 8). Of the eight studies based in England, one was a systematic review and included two of the identified studies; these two studies are presented in Table 8 but findings are not further discussed in the text as these are included in the review by Evans *et al*, 2010.⁸³ The remaining studies were cross-sectional. Children's ages ranged from 4-19y. Four studies were carried out in primary schools and three in secondary schools. Various dietary data collection methods were used which included: observational, weighed intakes, estimated weighed intakes and a 24hour recall. A summary of the main study characteristics and findings is shown in Table 8. The systematic review is not included in Table 8. These findings will be referred to at the end of the section below on nutrient intake.

Nutrient intake

A number of macro- and micronutrients were examined in these studies. Not all nutrients were reported in each study (see Table 9). Table 9 is provided to give a tabular summary by study of the nutrients reported and whether the individual studies found a statistically significant difference between lunch type. Whether school or home-packed lunches were higher or lower in nutritional content is discussed narratively below. For a number of nutrients examined the findings were consistent across studies. Children who ate a school lunch had a consistently lower intake from per cent energy from fat,⁸⁴⁻⁸⁶ saturated fat⁸⁴⁻⁸⁶, and NMEs,^{84, 85} and absolute amounts of fat,^{84, 87-89} and sodium^{84, 86, 87, 89} compared with children having a home-packed lunch. Children eating a school lunch also had consistently higher mean intakes of protein,⁸⁴⁻⁸⁸ NSP,⁸⁴⁻⁸⁷ zinc,⁸⁴⁻⁸⁷ folate⁸⁴⁻⁸⁷ and vitamin A.^{84, 86-89} Four out of the seven studies found no statistically significant difference in children's absolute intake of saturated fat.⁸⁵⁻⁸⁸ For the remaining six nutrients: mean energy, carbohydrate, absolute amounts of sugar, calcium, iron and vitamin C the findings on children's mean intake between school and home-packed lunches were inconsistent across

studies (see Table 10). The inconsistencies in these nutrients may be due to methodological differences. For example, different dietary data collection methods were employed and the numbers of days dietary data were collected varied. Inconsistencies may also be explained due to the variation in foods served and available for children to select from on the various days of dietary data collection.

Evans *et al*, 2010⁸³ undertook a meta-analysis that included seven UK based studies from 1990 to 2007 and examined the difference between children's lunchtime nutrient intake from a school or home-packed lunch. All studies included children who attended primary school only. The studies included used a range of dietary collection methods, which included: 7day weighed, 3day weighed, and 1day observation. They examined the same nutrients as those presented in Table 9, but did not report on per cent energy from fat, saturated fat or NMES. They reported that children's mean intakes of saturated fat, carbohydrate, total sugar, NMES, and sodium were lower in school lunches compared with home-packed lunches, but also, iron. Although the difference between lunch types widened between the two time points (pre and during the mid-implementation phase of the policy) there was no evidence found that this was statistically significant.

Table 8 Characteristics of included studies examining school and home-packed lunches combined (lunchtime)

Study characteristics: school and home-packed lunches								
Study	Country	School (n)	Children (n)	Age/school grade	Aim	Design & method	Data used	Key findings
Rogers <i>et al</i> 2007 ⁹⁰	UK (England)	Primary	621	7y	Examine food and nutrient intake	<ul style="list-style-type: none"> ➤ Sub-cohort of the Avon longitudinal study ➤ 3d un-weighed: 2 week and 1 weekend day 	Pre-policy	<ul style="list-style-type: none"> ➤ In both lunch types energy, NSP, calcium, iron, folate below recommendations; fat and sat fat above ➤ School lunch: higher protein, NSP and most micronutrients; lower sugar and per cent energy sat fat (p<0.001) ➤ Fruit & vegetable intake below recommendations
Rees <i>et al</i> 2008 ⁹¹	UK (England)	Primary (4)	120	6-11y	Compare food and nutrient intakes	<ul style="list-style-type: none"> ➤ Cross-sectional ➤ 1d observation 	Mid-implementation	<ul style="list-style-type: none"> ➤ Energy and protein intakes similar ➤ School lunch: higher per cent energy from fat p<0.001; less per cent energy from sat fat p=0.021 and sugar p<0.001 than packed lunches ➤ School lunch: less sodium and calcium (p<0.001 for both) but more iron p=0.016
Golley <i>et al</i> 2010 ⁸⁷	UK (England)	Primary (6)	123	8-10y	Examine lunchtime choices and intake	<ul style="list-style-type: none"> ➤ Cross-sectional ➤ 2d weighed 	Mid-implementation	<ul style="list-style-type: none"> ➤ School lunch: nutrient density significantly better: protein (p=0.001); fat (p=0.02); NSP (p=0.005); vitamin A (p=0.046); folate (p=0.002); iron (p=0.009) and zinc (p=0.007)

Table 8 continued								
Study characteristics: school and home-packed lunches								
Study	Country	School (n)	Children (n)	Age/school grade	Aim	Design & method	Data used	Key findings
Pearce <i>et al</i> 2011 ⁸⁴	UK (England)	Primary (136)	10002	4-12y	Compare key differences	<ul style="list-style-type: none"> ➤ Cross-sectional ➤ 1-5d ➤ Weighed intake pre and post (packed lunch) ➤ Weight of left-overs subtracted from average portion weight in school lunch 	Post-policy	<ul style="list-style-type: none"> ➤ In both lunch types protein, fat, saturated fat and vitamin C met recommendations ➤ School lunch: more protein, NSP, folate and zinc ($p < 0.001$ for all) than packed lunches ➤ School lunch: less fat, saturated fat, NMES and sodium ($p < 0.001$ for all) ➤ School lunch: less calcium, vitamin C and iron ($p < 0.001$ for all)
Pryne <i>et al</i> 2011 ⁹²	UK (England)	Secondary (18)	757	14-15y	Compare food and nutrient intake	<ul style="list-style-type: none"> ➤ Cross-sectional ➤ 4d estimated dairies: 2 week and 2 weekend days 	Pre-policy	<ul style="list-style-type: none"> ➤ In both lunch types a number of nutrients were below recommendations ➤ Boys: school lunches had more protein ($p = 0.009$), folate ($p = 0.028$), but also more sodium ($p < 0.001$). Girls: school lunches had more saturated fat and sodium ($p < 0.001$ both)
Hur <i>et al</i> 2011 ⁸⁸	USA	Primary (2)	129	9-11y (Grades 4-5)	Compare food, nutrient and energy intake	<ul style="list-style-type: none"> ➤ Cross-sectional ➤ 1d observational 	Post-policy	<ul style="list-style-type: none"> ➤ School lunches: less energy ($p = 0.048$), fat ($p = 0.003$) and added sugars ($p < 0.001$); no difference in per cent energy from fat ($p = 0.071$) ➤ School lunches: less fruit but more vegetables ($p < 0.001$ for both)

Table 8 continued								
Study characteristics: school and home-packed lunches								
Study	Country	School (n)	Children (n)	Age/school grade	Aim	Design & method	Data used	Key findings
Pearce <i>et al</i> 2012 ⁸⁵	UK (England)	Secondary (11)	497	11-16y	Compare key differences	<ul style="list-style-type: none"> ➤ Cross-sectional ➤ 1-5d ➤ Weighed intake pre and post (packed lunch) ➤ Weight of left-overs subtracted from average portion weight in school lunch 	Post-policy	<ul style="list-style-type: none"> ➤ In both lunch types protein, fat, saturated fat and vitamin C met standards ➤ School lunch: more protein, NSP, folate and zinc than packed lunches $p < 0.001$ ➤ School lunch less fat, saturated fat, NMES and sodium ($p < 0.001$ for all), but also less calcium, vitamin C and iron ($p < 0.001$ for all)
Taylor <i>et al</i> 2012 ⁸⁹	Canada	Primary (44)	1980	10-12y (Grades 5-6)	Assess nutritional quality of food consumed	<ul style="list-style-type: none"> ➤ Cross-sectional ➤ 1d in-class survey using a recall method 	Post-policy	<ul style="list-style-type: none"> ➤ School lunch: higher nutrient density of calcium, zinc, vitamin A ($p < 0.0001$ for all) ➤ School lunch: less iron, vitamin C and folate ($p < 0.0001$ for all) than packed lunches ➤ School lunch: higher protein but also more fat and sat fat ($p < 0.0001$ for all) ➤ School lunch: less sodium ($p < 0.0001$)

Table 8 continued								
Study characteristics: school and home-packed lunches								
Study	Country	School (n)	Children (n)	Age/school grade	Aim	Design & method	Data used	Key findings
Stevens <i>et al</i> 2012 ⁸⁶	UK (England)	Secondary (80)	7730	10-19y	Compare food choices and nutrient intakes	<ul style="list-style-type: none"> ➤ Cross-sectional ➤ 1-5d ➤ Weighed intake pre and post (packed lunch) ➤ Weight of left-overs subtracted from average portion weight in school lunch 	Post-policy	<ul style="list-style-type: none"> ➤ In both lunch types protein, NMES, fat, sat fat, sodium and vitamin C met recommendations; neither met iron, zinc or calcium ➤ School lunches: more energy, protein, iron and zinc ($p < 0.001$ for all); ➤ School lunches: less per cent energy (% E) fat and sat fat ($p < 0.001$ for both); no difference in % E NMES ($p = 0.703$)

Table 9 Nutrients reported in studies examining school and home-packed lunches combined (lunchtime)

Nutrient	Study & country						
	Golley <i>et al</i> 2010 ⁸⁷	Pearce <i>et al</i> 2011 ⁸⁴	Prynne <i>et al</i> 2011 ⁹²	Hur <i>et al</i> 2011 ⁸⁸	Pearce <i>et al</i> 2012 ⁸⁵	Taylor <i>et al</i> 2012 ⁸⁹	Stevens <i>et al</i> 2013 ⁸⁶
	England	England	England	USA	England	Canada	England
Energy*	S [†]	S	S	S	S	S	S
Fat (%)	NR [‡]	S	NR	NS [§]	S	NR	S
Saturated fat (%)	NR	S	NR	NR	S	NR	S
NMES (%)	NR	S	NR	NR	S	NR	NS
Fat (g)	S	S	NS	S	NS	S	NS
Saturated fat (g)	NS	S	S	NS	NS	NR	NS
Carbohydrate (g)	NS	S	S	S	S	S	S
Protein (g)	S	S	S	S	S	S	S
NSP (g)	S	S	NS	NS	S	S	S
Sugar (g)	NS	S	NS	S	NS	S	NS
Sodium (mg)	S	S	S	S	NS	S	S
Calcium (mg)	NS	S	NS	S	NS	S	NS
Iron (mg)	S	S	NS	NS	S	S	S
Zinc (mg)	S	S	NR	NR	S	S	S
Folate (µg)	S	S	S	NS	S	S	S
Vitamin C (mg)	NS	S	NS	NS	S	S	NS
Vitamin A (µg)	S	S	NR	S	NS	S	S

*Unit for measurement not reported in table as studies report in Kcal/MJ

[†]S nutrient reported; statistically significant difference between school and home-packed lunch

[‡]NR nutrient not reported

[§]NS nutrient reported; no statistically significant difference between school and home-packed lunch

Table 10 Inconsistencies in nutrients reported in studies examining school and home-packed lunches combined (lunchtime)

	Golley <i>et al</i> 2010 ⁸⁷ England	Pearce <i>et al</i> 2011 ⁸⁴ England	Prynne <i>et al</i> 2011 ⁹² England	Hur <i>et al</i> 2011 ⁸⁸ USA	Pearce <i>et al</i> 2012 ⁸⁵ England	Taylor <i>et al</i> 2012 ⁸⁹ Canada	Stevens <i>et al</i> 2013 ⁸⁶ England
Nutrient							
Energy*	↓ [†]	↓ [‡]	↑(girls)	↓	↑	↓	↑
Carbohydrate (g)	NS [§]	↓	↑ (girls)	↓	↑	↓	↑
Sugar (g)	NS	↓	NS	↓	NS	↓	NS
Calcium (mg)	NS	↓	NS	↑	NS	↑	NS
Iron (mg)	↑	↓	NS	NS	↑	↓	↑
Vitamin C (mg)	NS	↓	NS	NS	↑	↓	NS

* Unit for measurement not reported in table as studies report in Kcal/MJ

[†]↓ indicates a lower nutrient intake in school compared with a home-packed lunch

[‡]↑ indicates a higher nutrient intake in school compared with a home-packed lunch

[§]No significant difference by lunch type

Food and drink intake

Out of the seven studies, only one did not report findings on food and drink intake, Taylor et al, 2012.⁸⁹ A few of the findings related to food-based standards are presented: fruit, vegetables, confectionery, and 'other drinks'. All six studies reported on fruit and vegetable intake. Four out of the six studies reported children's fruit intake was lower in school lunches compared with home-packed lunches,^{84, 87, 88, 92} five reported vegetable intake was higher in school lunches.^{84, 85, 87, 88, 92} Four out of the six studies^{84-86, 92} reported children's consumption of confectionery and 'other drinks' (i.e. drinks that did not comply with the standards). Confectionery intake in school lunches was found to be lower in three studies compared with home-packed lunches.^{84, 85, 92} Children's intake of 'other drinks' was found to be higher in school lunches compared with home-packed lunches in two studies.^{85, 86} These two studies were based in secondary schools.

Comparison of children's mean dietary intake against nutritional recommendations for school lunch

Four out of the seven studies^{85, 86, 88, 92} reported on children's mean intakes from school and home-packed lunches compared with the implementation of food and nutrient-based standards. Although the recommendations apply to school lunches only, the authors did compare both school and home-packed lunches against these. To summarise, no study reported that children's mean intakes in either a school or home-packed lunch met *all* the recommendations. For example, Prynne *et al*, 2011⁹² found a high percentage of children consuming either a school or home-packed lunch did not meet the recommendations. Stevens *et al*, 2013⁸⁶ found mean intakes of fat, saturated fat and NMEs did not meet recommendations in children consuming either a school or home-packed lunch. For the majority of micronutrients reported these were not met in children consuming a school or home-packed lunch.

Socio-economic effects

One study not included in Table 8 or in the preliminary description of studies is that by Cullen *et al*, 2009.⁹³ They reported the impact of the Texas Public School Nutrition Policy on children's food and nutrient intake from four lunch sources: national school lunch program (NSLP: a program providing free or reduced cost lunches to eligible children), home-packed, snack bar and vending machine across the socio-economic spectrum. Children in grades 6-8 in two schools (one middle and one a low socio-economic status school) were eligible to participate. Children completed food records immediately after consuming their school lunch: lunch records=1718 in 2001-02 (pre-policy) and lunch records=6756 in 2005-06 (post-policy implementation). School socio-economic status (SES) was measured on free school meal eligibility (40% of students were eligible in the middle SES school and 80% were eligible in the low SES school).

For children consuming a lunch from the NSLP program they reported statistically significant year by SES interactions for a number of nutrients. Post-policy implementation, children in the middle SES school had higher intakes of energy ($p < 0.001$), protein (< 0.001), NSP (< 0.0055), vitamin A (< 0.0055), iron ($p < 0.001$) and calcium ($p < 0.001$). They were also found to have a higher per

cent energy from fat ($p < 0.001$) and sodium ($p < 0.0055$). For children in the low socio-economic school no statistically significant differences were found pre to post-policy implementation.

For children consuming a home-packed lunch they found no evidence of a change in nutrient intakes. However, they did find that for some foods consumed: sweetened beverages, dessert foods and snack chips there were significant year by SES interactions. Children from the mid socio-economic schools had higher intakes ($p < 0.001$ for all) post-policy implementation; differences in the lower socio-economic groups were not statistically significant. Findings reported that differences (improvements) in consumption from snack bars and vending machines were found in children attending the middle SES school but not in the lower SES school.⁹³

Limitations

There are a number of limitations with these studies that examined the impact of school food policies on children's dietary intake in a school or home-packed lunch. To start, the studies only examined the impact of the school food policies at one point of time (e.g. either pre or post-policy implementation). None of the studies reported the impact by examining the difference in children's dietary intake from either a school or home-packed lunch pre to post-policy implementation.

The studies used various dietary data collection methods and there were some limitations with these. The key limitation is that majority of studies only reported findings based on one day of dietary data collection.^{86, 88, 89, 93} This does not account for day to day variation in children's dietary intake. A limitation in assessing children's dietary intake against the recommendations is that the data collection period did not cover the period that recommendations apply to (i.e. typically a 3-week menu cycle).

A limitation with the systematic review by Evans *et al*,⁸³ is that findings are prior to the full implementation of the food and nutrient-based standards to school lunch in England. Schools were therefore not expected to comply with the standards. This may explain why no statistically significant differences in children's nutrient intakes between lunch types were found.

A key limitation in the study by Cullen *et al*,⁹³ that examined the impact by SES is that no individual level demographic information was collected. SES was measured by free school meal eligibility at the school level. Furthermore, only two schools participated, thus limiting generalisability.⁹³

Questions that remain unanswered

Despite the limitations, there were some consistent findings. For the majority of macronutrients, a school lunch provides a healthier option. For example, children's per cent energy from fat and saturated fat⁸⁴⁻⁸⁶ and absolute amounts of mean sodium intake were lower.^{84, 85, 87, 89} Also, mean intakes of some micronutrients were higher e.g. zinc.⁸⁴⁻⁸⁷ However, the findings for micronutrients were less consistent. Therefore, there is some evidence that an average school lunch provides a 'healthier' option compared with a home-packed lunch. The two studies^{85, 86} that found drinks that did not comply with the recommendations and were consumed more in school lunches were both in secondary schools. This emphasises that school compliance with nutritional standards is important and also children's food choices from available foods.

No study compared the impact of the school food policies pre to post-policy implementation. Therefore, the question whether there is a widening gap between school and home-packed lunch is not answered by these studies. Furthermore, the question of whether a child's lunch type has an impact on their total diet is also not known.

3.4.2 Total diet: children's mean dietary intake

Description of studies

Five studies examined what children consumed in either a school, home-packed lunch or a comparison between school and home-packed lunch: one was based in the USA, one in Canada, one in Finland and two in England (see Table 11). All studies were cross-sectional. Children's ages ranged from 4-16y. Three studies were carried out in primary schools and two included primary and secondary schools. Various dietary data collection methods were used which included: a 24hour dietary recall, an internet-based questionnaire, a 4day observational method and a food frequency questionnaire. A summary of key study characteristics and findings is provided in Table 11. This section is not

broken down further into studies examining school lunch, home-packed lunch and school and home-packed combined due to the small number of studies.

Nutrient intake

The studies had different aims (see Table 11), thus comparisons across these studies are more limited.

Harrison *et al*, 2011⁹⁴ found there was no evidence of a difference by lunch type (school or home-packed lunch) on the macronutrients reported: energy, per cent energy from fat, carbohydrates, protein and absolute amounts of NSP. They found a marginally statistically significant difference in energy density. Children who consumed a school lunch had a less-energy dense diet compared with children who consumed a home-packed lunch ($p < 0.05$). Stevens *et al*, 2011⁹⁵ also reported the difference in mean macro- and micronutrients between school and home-packed lunches; they found no evidence of a difference. For one nutrient, zinc, they reported a difference between mean intake in children aged 4-7y who consumed a bought school lunch compared with a free school lunch ($p < 0.05$).

Clark *et al*, 2009⁹⁶ found all children who consumed a school lunch had a higher energy intake compared to children who did not eat a school lunch. For the high school children they found evidence of a statistically significant difference in mean intakes of vitamin C; children consuming a school lunch had a lower intake ($p < 0.05$). Mean intakes of calcium ($p < 0.05$), fibre ($p < 0.05$), folate ($p < 0.01$), and also sodium ($p < 0.05$) were higher in children consuming a school lunch.

Fung *et al*, 2013⁹⁷ is the only study to examine the change in mean intakes from pre to post-policy implementation. However, the findings are not reported by lunch type. They found post-policy children had a lower mean energy intake, per cent energy fat, but also lower intakes of vitamin C, folate, vitamin A, zinc and calcium.

Food and drink intake

Four out of the five studies reported findings on food and drink intake. Harrison *et al*, 2011⁹⁴ reported that children consuming a school lunch had a higher

intake of chips, sweet snacks, and vegetables ($p < 0.05$ for all). For children consuming a home-packed lunch they found a higher mean intake of fruit, squash/cordial, savoury snacks and confectionery ($p < 0.05$). Stevens *et al*, 2011⁹⁵ found no evidence of a difference in mean vegetable intake by lunch type. There was only evidence of a difference in mean fruit intake for children aged 4-7; children who consumed a bought school lunch had a lower intake than children who ate a home-packed lunch. Findings for chips, crisps and confectionery were similar to those found by Harrison *et al*. Fung *et al*, 2013⁹⁷ did not find evidence of a change in mean fruit and vegetable intake; mean intakes of sugar-sweetened beverages decreased ($p < 0.001$).

A study by Tilles-Trikkonen *et al*, 2011⁹⁸ explored how the quality of a school lunch was reflected in overall eating patterns. They compared two groups of children: those that had a 'balanced' school lunch (if it included a main dish, salad and bread at least 3-4 days/week) and those that did not. School children who had a balanced school lunch were found to have 'healthier' eating patterns (see Table 11), and parents who paid more attention to the quality of the diet ($p = 0.021$). Children were also found to make 'healthier' food choices. For example, they consumed less pizza ($p = 0.010$), and soft drinks ($p = 0.004$), but more vegetables ($p < 0.001$), fruit and berries ($p < 0.001$). However, for a number of foods: hamburgers, hot dogs, French fries, sweets and chocolate, vegetables, ice cream and buns/cookies, they found no evidence of a difference in consumption.⁹⁸

Socio-economic effects

Two studies^{94, 97} adjusted for socio-economic variables in the analysis; one used parental educational attainment;⁹⁴ the other household income.⁹⁷ Neither study reports that there was evidence of a difference by SES. The study by Stevens *et al*, 2011⁹⁵ does examine the difference in school lunch, free school lunch and home-packed lunch but only in a 'low' income population.

Limitations

Few studies have examined the impact of a school food policy on children's dietary intake. The outcomes in the five studies are not consistent. Therefore, the ability to draw a clear message is limited. In three of the studies⁹⁴⁻⁹⁶ one used dietary data collected pre-policy;⁹⁵ one used dietary data from the mid-implementation phase;⁹⁴ and one post-policy.⁹⁶ The study by Stevens *et al*, 2011⁹⁵ did not find any evidence of a statistically significant difference by lunch type in children's mean nutrient intakes. This may be associated with the fact dietary data was collected pre-policy. Also, all three of these studies only examined the difference at one point of time. Therefore, evaluating the impact pre to post-policy implementation has not been reported in these studies. One study by Fung *et al*, 2013⁹⁷ did evaluate the impact of policy implementation on children's total diet pre to post-policy, but did not report the impact by different lunch types.

The studies used various dietary data collection methods. In addition, four of the studies⁹⁵⁻⁹⁸ only used one day of dietary data, thus day to day dietary variation is not accounted for.

Questions that remain unanswered

Only one study⁹⁷ identified in this narrative literature review used a pre and post-policy study design to examine the impact of a school food policy on children's total dietary intake. The following questions are not answered by the above studies:

- i. does the implementation of school food policies have an equitable impact on children's diets across the socio-economic spectrum?
- ii. by implementing school food policies has the gap between school and home-packed lunches changed?, and there is limited evidence on
- iii. does the implementation of school food policies impact on children's total dietary intake? (pre and post-policy implementation).

Table 11 Characteristics of studies included examining school, home-packed or school and home-packed lunches combined (total diet)

Study characteristics: school lunches (total diet)								
Study	Country	School (n)	Children (n)	Age/school grade	Aim	Design & method	Data used	Key findings
Clark <i>et al</i> 2009 ⁹⁶	USA	Primary Secondary (287 in total)	2134	6-18y (Grades 1-12)	Explore the relationship between school lunch and nutritional quality of children's diets	<ul style="list-style-type: none"> ➤ Cross-sectional ➤ 24hr dietary recalls 	School nutrition dietary assessment study (2004 to 2005)	<ul style="list-style-type: none"> ➤ School lunch: associated with more adequate intakes of calcium, vitamin C and folate in middle school and high school children. In high school children they also had excess sodium intake ➤ Majority of children have excess saturated fat regardless whether they have school lunch or not
Tilles-Tirkkonen <i>et al</i> 2011 ⁹⁸	Finland	Primary (11) Middle (1)	531	11-16y	Explore how quality of school lunch reflects in total diet	<ul style="list-style-type: none"> ➤ Cross-sectional ➤ Internet-based questionnaire 	Post-policy (Spring 2010)	<ul style="list-style-type: none"> ➤ Children who had a 'balanced' school lunch had a healthier eating pattern at home as opposed to those with an 'imbalanced' school lunch; they consumed vegetables in every meal (p=0.002), fruit was offered daily (p=0.007) and soft drinks offered less (p=0.006) ➤ Balanced school lunch consumers also ate healthier snacks, for example, more fruit/berries (p<0.001); less salty snacks (p=0.026) and less soft drinks (p=0.010)

Table 11 continued								
Study characteristics: school and home-packed lunches (total diet)								
Study	Country	School (n)	Children (n)	Age/school grade	Aim	Design & method	Data used	Key findings
Harrison <i>et al</i> 2011 ⁹⁴	UK (England)	Primary (90)	1626	9-10y	Examine intake (school and packed lunch) against food-based standards Examine lunchtime contribution to overall dietary intake	➤ Cross-sectional ➤ 4d observation	Mid-implementation (April to July 2007)	➤ School lunch: more NSP, and a less energy dense diet than packed lunches ($p < 0.05$ for both) ➤ Children eating a school lunch consumed more vegetables, sweet snacks and chips - this was reflected in total diet
Stevens <i>et al</i> 2011 ⁹⁵	UK (England)	Primary	680	4-11y	Examine food and nutrient intake in school (free and paid) and packed lunch Examine contribution of lunch type to total diet	➤ Cross-sectional ➤ 24h dietary recalls	Pre-policy Low-income diet & nutrition survey (Nov 2003 to Jan 2005)	➤ In 4-7y olds free school meals provided less sodium, per cent energy from fat and sat fat compared to packed lunches, but also less folate ➤ In 4-7y & 8-11y olds there was no difference in energy and nutrients by lunch type
Fung <i>et al</i> 2013 ⁹⁷	Canada	Primary	10723	11-12y (Grade 5)	Assess dietary trends pre and post-implementation of a school nutrition policy	➤ Cross-sectional ➤ Food frequency questionnaire	Pre and post-policy (2003 and 2011)	➤ Mean energy intake decreased ($p < 0.001$) ➤ Per cent energy from fat decreased and sodium ($p < 0.001$ for both); but also vitamin C, folate, vitamin A, zinc and calcium ($p < 0.001$ for all)

3.5 Overall summary and limitations of the literature

Since 2006 there have been considerable changes to the food and drink that can and cannot be served in school lunches in England. Internationally there have also been changes to school food. This narrative literature review summarised findings from 27 studies that examined the impact of a school lunch, home-packed lunch or a comparison of both lunch types on children's dietary intake at lunchtime or in their total diet. The narrative review also presented findings from studies that compared children's intakes against nutritional standards. An overall summary of geographical location, period of dietary collection, data used (e.g. pre-policy implementation) and the age group of children (e.g. primary school age) by lunch type is provided below.

Table 12 A summary of the geographical location, period of data collection, data used and the age group of children by lunch type of the included studies

	School lunch <i>n</i> =8	Home-packed lunch <i>n</i> =3	School & home-packed lunch <i>n</i> =10*	Total diet <i>n</i> =5
Location				
UK	5	1	7	2
Europe	1	1	0	1
USA	2	1	2	1
Canada	0	0	1	1
Dietary data				
1 day	5 [†]	3	7 [†]	4
>1 day	3	0	3	1
Data used				
Pre policy	3	n/a	4	2
Post-policy	2	n/a	6	2
Pre & post-policy	3	n/a	0	1
Age group				
Primary school	3	2	6	3
Secondary (including middle)	3	1	4	0
Both primary & secondary	2	0	0	2

*The systematic review by Evans *et al*, 2010 is not included in this table

[†] There is potential in two studies for children to have completed more than one day

3.5.1 Lunchtime

3.5.1.1 School lunch

A small number of studies ($n=3$)^{73, 78, 79} examined the difference in children's mean nutrient intake at school lunch pre to post-policy implementation. While there is some evidence of an improvement (reduced intake) in children's consumption of per cent energy fat, saturated fat and NMES. The findings for mean micronutrient intakes were less consistent. There is also some evidence of the importance of the foods available in schools and the impact on children's food choices.^{74, 78, 79} In the study by Vereecken *et al*, 2005⁷⁴ they found for children in the secondary schools, if soft drinks were available at school then children were more likely to consume them. Findings by Haroun *et al*, 2010⁷⁸ and Nicholas *et al*, 2013⁷⁹ found post-implementation of the nutritional standards to school lunch in England the provision of foods served had improved and this was reflected in children's food choices.

An important consideration highlighted by Martin *et al*, 2010⁷⁷ in evaluating the impact of school food policies on children's diets is the issue of when evaluations are undertaken. Martin *et al*, 2010⁷⁷ noted at the time of their study the recommendations had recently been implemented; therefore, schools may not yet have been fully compliant. Compliance by schools with food policies is an important issue. For example, Haroun *et al*, 2010⁷⁸ found in schools where food and nutrient provision complied with nutritional standards this was reflected in what children ate.

3.5.1.2 Home-packed lunches

A small number of studies ($n=3$)⁸⁰⁻⁸² have focused on children's mean food and nutrient intakes in home-packed lunches. The most commonly consumed items in home-packed lunches were crisps or savoury snacks, and biscuits or cookies.

Although the nutritional standards do not apply to home-packed lunches one study by Evans *et al*, 2010⁸² noted few home-packed lunches met the nutrient-based standards for NMES (18.5%), sodium (19.4%), iron (24.8%) and zinc (27.9%).⁸²

3.5.1.3 School and home-packed lunch

The majority of studies ($n=10$) identified in this narrative review have focused on the difference between children's mean nutrient intakes by lunch type. The findings highlight there is some evidence that children who consume a school lunch have a 'healthier' intake. For example, children who consume a school lunch have a lower per cent energy from fat, saturated fat and absolute amounts of mean sodium intake compared with children consuming a home-packed lunch.^{84-87, 89} However, the findings on micronutrients were less consistent. All of the studies only examined children's mean dietary intake from a school or home-packed lunch at one point of time (either pre or post-policy implementation).

Children who consume a school lunch were found to have a lower fruit but higher vegetable intake than children who consume a home-packed lunch.^{84, 87, 88, 92} Reasons for this may be: vegetables are offered with the school lunch, as opposed to a child having to choose the fruit as the dessert option, or the availability of fruit.

3.5.2 Total diet

A small number of studies ($n=5$) have examined the impact of implementing a school food policy on children's mean total dietary intake. The study aims were varied which limits the ability to draw a clear conclusion. Two studies^{94, 95} found a child's lunch type had no effect on total diet. However, both of these studies used dietary data collected prior to full implementation of the school food policy. This again emphasises the importance of the timing of evaluations as noted by Martin *et al.*⁷⁷ Two studies^{96, 97} found some evidence that implementation of a school food policy can potentially have a positive impact on children's total diet. A limitation with these two studies is they collected dietary data for one day only. A further study⁹⁸ highlighted the influence of parents on the nutritional quality of children's diets. The authors found children who had a balanced meal also had parents who paid more attention to the quality of their dietary intake.⁹⁸

3.5.3 Key limitations

The majority of studies used a cross-sectional study design (this is further discussed in Chapter 6). More than half of the studies included only one day of

dietary data collection. None of the studies that examined children's mean dietary intake by lunch type (the comparison between school or home-packed) used a pre and post-policy implementation design. Only four studies examined the impact of school food policies on children's dietary intake pre to post-policy implementation: three examined the impact of nutritional standards on children's dietary intake from a school lunch at lunchtime only^{73, 78, 79} and one examined the impact on total diet.⁹⁷ Socio-economic status was measured principally at the school level.

What is known

This narrative review highlighted overall there is some evidence that:

- i. children's mean nutritional intake from a school lunch has improved post-policy implementation - both in the study based in the USA⁷³ and two studies based in England^{78, 79}
- ii. children who consume a school lunch compared with children consuming a home-packed lunch have a 'healthier' intake. For example, children who consume a school lunch have a lower per cent energy from fat, saturated fat and absolute amounts of mean sodium intake.^{84-87, 89}

On reflection of the narrative literature review three concepts emerged: the importance surrounding the timing of evaluations examining the impact of school food policies,⁷⁷ children's food choice from the foods available and school compliance with the policies implemented.^{74, 78, 79}

What is not known

This narrative review highlighted a number of questions that are not answered by these studies, for example:

- i. what are the wider impacts of a change in school food policy to children's total dietary intake?
- ii. is the impact of a school food policy equitable across the SES for children that consume a school lunch?

3.6 Rationale

There are a number of reasons why it is important to evaluate a change in school food policy and the potential impact on children's diets. Firstly, this narrative review has highlighted that only a small number of studies ($n=4$) in the UK or internationally have evaluated the impact of a school food policy pre to post-policy implementation.^{73, 78, 79, 97} Three of these studies^{73, 78, 79} examined the impact only at lunchtime and one study⁹⁷ examined the impact on children's total diet. Therefore, there is a need to build on the existing evidence of the impact of school food policies on children's diets

Secondly, this narrative review found a small number of studies have examined the wider impacts of school food policy changes, such as the impact on children's total diet or across the socio-economic spectrum. Aside from one study,⁹⁷ a key limitation with the studies that examined these outcomes is they do not examine the impact pre and post-policy implementation on children's diets. In implementing school food policies there is the potential for both positive and unintended negative outcomes.^{97, 98} For example, restricting the provision of certain foods (e.g. chips and increased availability of fruit and vegetables) may have a positive impact on children's diets (e.g. reduced fat intake and increased micronutrient intake). Conversely, there is the potential that the implementation of school food policies may not have an equitable impact on children's diets across the socio-economic spectrum. This may be associated with children's individual food choice, or school lunch take-up which may decrease. Only a small number of studies have examined the impact on total diet and considered the SES effect. Thus, there is a need for further research to develop the evidence-base on the potential wider impacts of school food policies on children's diets.

Thirdly, school food has received considerable economic investment.⁶⁵ From a cost-effectiveness point of view evaluating the impact is also important. However, while this is an important aspect the cost-effectiveness of school food policies is beyond the remit of Papers II-IV.



Fourthly, the narrative review of the literature highlighted some methodological limitations. Approximately half of the studies included dietary data from one-day only. Therefore, children's day to day variation in dietary intakes was not

accounted for. In addition, the studies cited in the narrative literature review used school level classification of SES. This highlights that additional evaluations need to address some of the methodological issues.


Chapter 4 provides a detailed account of the dietary data methods used in Papers I-IV. Each paper includes a short methods section. It is important to mention at this point that there is an overlap in content between Chapter 4 and the four papers in the recruitment, classification of SES and dietary data collection methods.^{39, 47, 48} Examiners may prefer to read only the methodological paper included in Chapter 4. The full dietary data collection methods are included as a reference for interest. As noted at the end of section 2.3 during my PhD studies I co-authored a report for the Department of Health (Public Health Research Consortium).⁴² This report also included an overview of the methods.

3.7 Research questions addressed in papers

Dietary outcome evaluation

- i. Did the introduction of food and nutrient-based standards impact on lunchtime and total dietary intake in children aged 4-7y and 11-12y?  Paper II and III
- ii. Did the introduction of nutritional standards for school lunches have an equitable impact on children's diets across the socio-economic spectrum?  Paper III and IV
- iii. Did school lunch take-up change across the socio-economic spectrum following the introduction of food and nutrient-based standards?

Methodological issues

- iv. Did the use of passive or active consent affect consent and completion rates, or dietary data quality across the socio-economic spectrum?  Paper I

Chapter 4 Methods

Chapter Overview:

The aim of this chapter is to present a more detailed account of the dietary data methods used compared with those reported in individual papers. The following aspects are considered:

- Ethical approval
- Study design and setting
- Recruitment
- Dietary data collection and coding; data processing and handling
- Socio-economic status
- Statistical analysis

Paper I is presented in section 4.9 which examines the use of passive and active consent on consent and completion rates, and dietary data quality across the socio-economic spectrum.

4.1 Ethical approval

Ethical approval was granted by Newcastle University ethics committee (reference 000011/2007; see Appendix A).

4.2 Overview of study design and setting

Repeated cross-sectional surveys were undertaken in two counties in North East England: Tyne and Wear (Newcastle-upon-Tyne; primary schools) and Northumberland (Morpeth, Ashington and Newbiggin-by-the-sea; middle schools) see Figure 3. The data used in the four included papers were from: primary school surveys 1 & 3 (Paper II and IV), middle school surveys 3 & 5 (Paper III) and middle school survey 4 & 5 (Paper I).

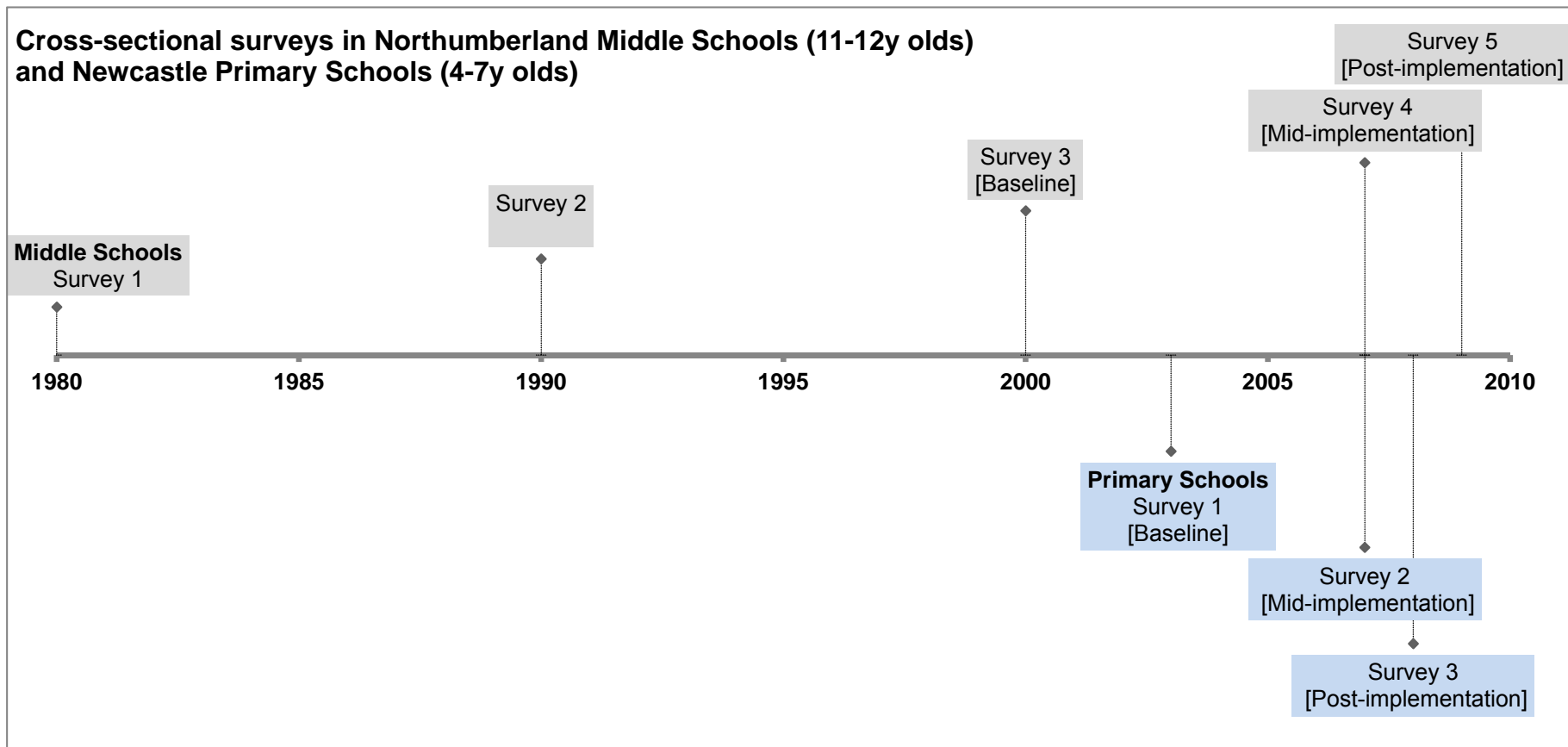


Figure 3 Cross-sectional surveys of Northumberland middle schools and Newcastle primary schools

4.3 Recruitment

For clarity, the methods employed in primary and middle schools are presented separately.

4.3.1 Primary schools

The pre-implementation survey had been completed as part of an earlier study and was used as baseline data.⁹⁹ The post-implementation survey used identical methods. A letter with study details was posted to head teachers of the 16 primary schools in Newcastle-upon-Tyne that had participated in 2003-04. This was followed up with a phone call to answer any questions and ascertain interest. If required, a school visit was arranged to discuss the study with the head teacher. This was a key aspect for this study; to recruit the same schools for which we had dietary data pre-implementation of the policy to enable us to compare nutrient intake pre and post-implementation.

Schools were originally selected in 2003-04 using the free school meal index¹⁰⁰ as a proxy measure for the level of deprivation in the school population to seek a balance across the socio-economic spectrum. The free school meal index indicates the percentage of children in a school eligible for free school meals. The same schools were invited to participate in 2008-09; only after consent by Head teachers were schools included. The results presented in Papers I and II include data collected from 12 schools for which comparable data were available from the two surveys.

All children in Reception, Year 1 and Year 2 (aged 4-7 years) were eligible to participate. A time was arranged with each school to talk to the children. This allowed the researcher to show the children the dietary data collection tools and provided an opportunity for them to ask questions. Each child received a letter with study details and a form requiring active parental consent to participate in the study (see Appendix B and C). Consent forms were collected from schools. Once data collection was completed schools received a fruit basket and book voucher to the value of £1 for each child that participated.

4.3.2 Middle schools

A letter with study details was posted to head teachers of the same six middle schools in Morpeth, Ashington and Newbiggin-by-the-sea that had participated in 1999-2000. This was followed up with a school visit to answer questions and ascertain interest. These areas were previously selected in 1980 to be representative of schools with catchment populations across the socio-economic spectrum;¹⁰¹⁻¹⁰³ these schools continued to participate in following surveys (Figure 3). The 1999-2000 data were collected as part of a series of studies conducted in Northumberland¹⁰²⁻¹⁰⁵ to track changes in dietary patterns and used as baseline data in this study.

As shown in Figure 3 a mid-implementation survey was undertaken in middle schools. During discussions, head teachers suggested consent should be changed from active 'opt-in' (as used in the previous studies in these schools) to passive 'opt-out'. The rationale was that by using active consent we excluded children whose parents failed to return forms sent by schools, rather than just those children whose parents actively did not want their child to participate. After obtaining documented support from heads and school governors, an amendment to the Newcastle University Ethics approval was granted (reference00011/2009) for the use of passive consent in 2009-10 (see Appendix D and E). One head preferred that the school continued to use active consent (this was the smallest school) and the decision was taken to retain this school despite a different consent method used. Regardless of method of parental consent (active or passive) children could still exclude themselves from the study by not completing food diaries and were free to leave the study at any time.

All children in year 7 were eligible to participate. A suitable time was arranged with individual schools to present the study via a power-point presentation, show children the dietary data collection tools and allow an opportunity for them to ask questions. In 2009-10, each child received a parental information letter about the study and a consent form. However, they were only required to return the consent form if they *did not* wish their child to participate (Appendix F). On completion of the data collection schools received a fruit basket and book voucher to the value of £1 for each child that participated.

This change in recruitment procedure from 2007-2008 (mid-implementation) to 2009-2010 (post-implementation) led to research question 4:

Did the use of passive or active consent affect consent and completion rates, or dietary data quality across the socio-economic spectrum?

Findings and a discussion are presented in Paper I (see section 4.9).

4.4 Dietary data collection

Identical dietary data collection methods were used in each setting, primary or middle schools, as those used in the previous baseline surveys.

4.4.1 Primary schools

Four consecutive days of dietary consumption were collected for each participating child: three week days and one weekend day. A prospective, 24-hour food diary method (the Food Assessment in Schools Tool (FAST)), validated to record young children's dietary intake was used.⁹⁹

Food diaries were distributed in a clear plastic A5 wallet to participating children by class teachers on Tuesday afternoon enabling data collection to commence Wednesday morning. Each child's name, individual identification number (ID) and class were written on the front cover of individual food diaries. The food diaries were distributed to the children and went between school and home with the child. Full written instructions on how to complete the food diary were provided to parents. Parents completed the diaries at home. At each school, a team of trained observers and myself recorded dietary intake, including, breakfast and afterschool clubs.

Figure 4 shows the process for dietary data collection. Figure 5 shows an example of a primary school child's completed food diary for one week day. The diary design enabled categorisation of foods into 'school lunch', 'home-packed lunch', and 'food eaten at home'. Section 4.5 discusses the procedure for dietary data coding. See Appendix G for a full image of the dietary data collection tool used in primary schools.

4.4.1.1 Recruitment and training of lay observers

Due to the age of the children and the observational dietary data collection method lay observers were recruited. Adverts were placed on the Newcastle University website and in the Evening Chronicle newspaper; selected candidates were asked to attend to interview. Interviews were conducted by Professor Ashley Adamson and myself. Successful candidates were invited to attend a training day. The training day covered a number of topics, for example, the background to the study, development of the 'FAST' food diary along with a practical session in its application. They also received information about completion of timesheets, travel expenses, availability for shifts in schools, the process for obtaining Criminal Records Bureau clearance and obtaining a personal University identification card required in schools. The training programme and practical aspects were delivered by myself under the supervision of Professor Ashley Adamson.

4.4.1.2 Staff protocol for working in schools

An enhanced Criminal Records Bureau clearance check was obtained for all staff working in schools. University identification badges were worn in schools at all times.

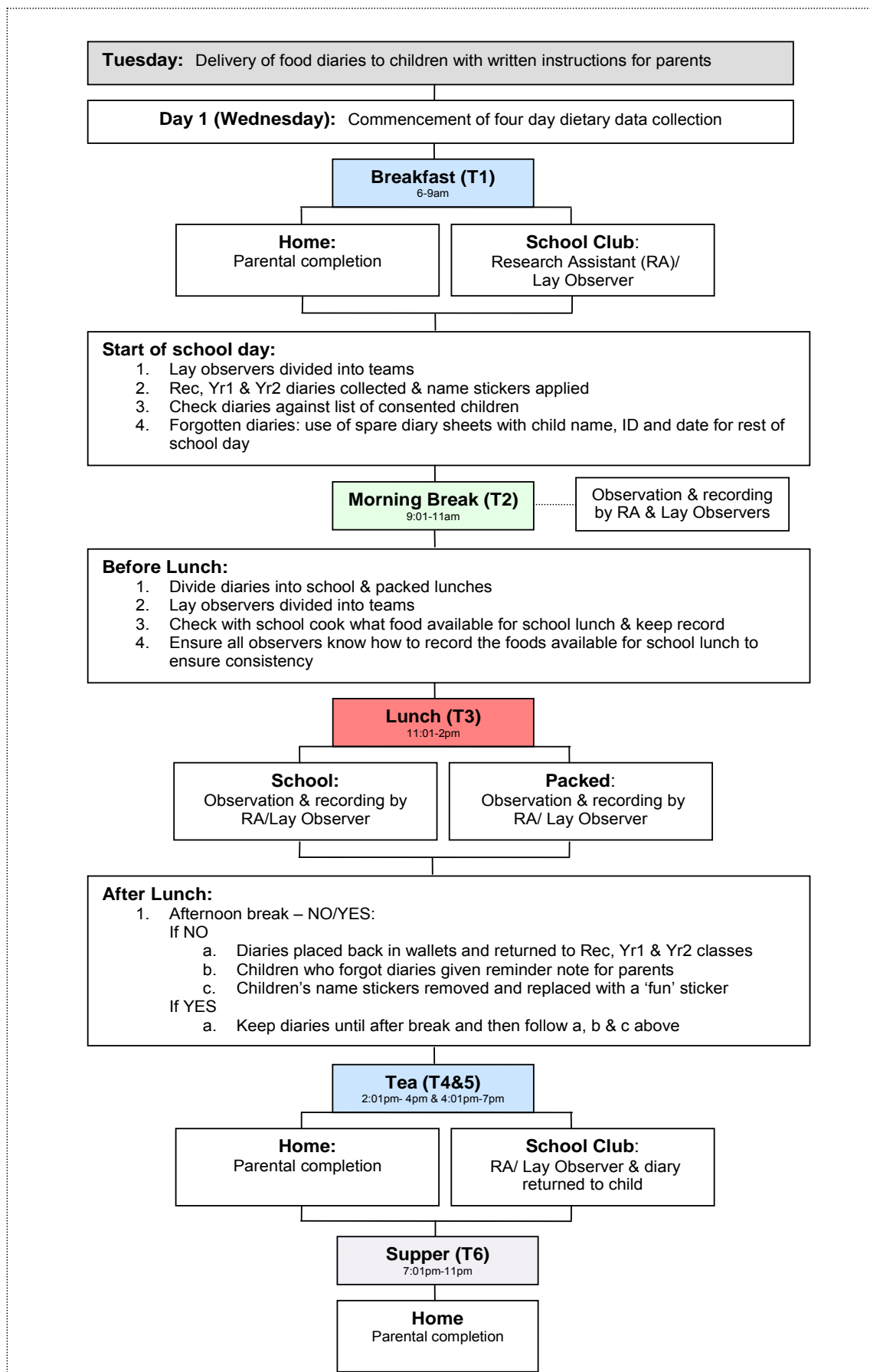


Figure 4 Process for dietary data collection in primary schools

Day 1 Wednesday 30th January 2008

School Lunch
 Packed Lunch

6.00am - 9.00am Time slot 1	<input type="checkbox"/> White bread or toast <input type="checkbox"/> Wholemeal bread or toast <input type="checkbox"/> Margarine <input type="checkbox"/> Butter <input type="checkbox"/> Jam or preserves <input type="checkbox"/> Weetabix <input type="checkbox"/> Cornflakes <input type="checkbox"/> Frosties	<input type="checkbox"/> Coco Pops <input type="checkbox"/> Rice Krispies <input checked="" type="checkbox"/> Milk full-fat with cereal <input type="checkbox"/> Milk, semi-skimmed with cereal <input type="checkbox"/> Banana <input type="checkbox"/> Egg <input type="checkbox"/> Yoghurt <input type="checkbox"/> Sugar	<input type="checkbox"/> Biscuits—not chocolate <input type="checkbox"/> Biscuits—chocolate <input type="checkbox"/> Orange juice, unsweetened <input type="checkbox"/> Apple juice, unsweetened <input type="checkbox"/> Milk, full-fat drink <input type="checkbox"/> Milk, semi-skimmed drink <input type="checkbox"/> Squash—reduced sugar	<input type="checkbox"/> Squash <input type="checkbox"/> Tea with milk <input type="checkbox"/> Water 1152 Others 26g <u>Sugar Puffs</u>
9.01am - 11.00am Time slot 2	<input type="checkbox"/> White bread or toast <input type="checkbox"/> Wholemeal bread or toast <input type="checkbox"/> Margarine <input type="checkbox"/> Butter <input type="checkbox"/> Jam or preserves <input checked="" type="checkbox"/> Apple <input checked="" type="checkbox"/> Banana <input checked="" type="checkbox"/> Pear	<input type="checkbox"/> Tangerine, mandarin, satsuma <input type="checkbox"/> Crisps or savoury snacks <input checked="" type="checkbox"/> Biscuits—not chocolate <input type="checkbox"/> Biscuits—chocolate <input type="checkbox"/> Chocolate bar <input type="checkbox"/> Chocolate sweets <input type="checkbox"/> Sweets (not chocolate)	<input type="checkbox"/> Orange juice, unsweetened <input type="checkbox"/> Apple juice, unsweetened <input checked="" type="checkbox"/> Milk, full-fat drink <input checked="" type="checkbox"/> Milk, semi-skimmed drink <input type="checkbox"/> Squash—reduced sugar <input type="checkbox"/> Squash <input type="checkbox"/> Fizzy drink <input type="checkbox"/> Diet fizzy drink	<input type="checkbox"/> Water Others <u>Garlic (school)</u> <u>SF carrot</u>
11.01am - 2.00pm Time slot 3	<input checked="" type="checkbox"/> White bread or toast <input type="checkbox"/> Wholemeal bread or toast <input type="checkbox"/> Margarine <input type="checkbox"/> Butter <input type="checkbox"/> Cheese <input type="checkbox"/> Cheese spread / triangle <input type="checkbox"/> Baked beans <input type="checkbox"/> Fish fingers <input type="checkbox"/> Ham (103) <input checked="" type="checkbox"/> Chicken or turkey (not nuggets) <input type="checkbox"/> Sausage roll <input type="checkbox"/> Tuna, tinned <input type="checkbox"/> Eggs, boiled <input type="checkbox"/> Pasta, tinned, in tomato sauce	<input type="checkbox"/> Oven chips <input type="checkbox"/> Chips—fried <input type="checkbox"/> Potatoes—other <input type="checkbox"/> Peas <input type="checkbox"/> Sweetcorn <input type="checkbox"/> Carrots <input type="checkbox"/> Cucumber <input type="checkbox"/> Tomato <input type="checkbox"/> Crisps or savoury snacks <input type="checkbox"/> Ketchup <input checked="" type="checkbox"/> Gravy (164) <input type="checkbox"/> Apple <input checked="" type="checkbox"/> Banana (102) <input type="checkbox"/> Tangerine, mandarin, satsuma	<input type="checkbox"/> Grapes <input type="checkbox"/> Strawberries <input type="checkbox"/> Raisins <input type="checkbox"/> Biscuits—not chocolate <input type="checkbox"/> Biscuits—chocolate <input type="checkbox"/> Yoghurt / fromage frais <input type="checkbox"/> Cake or sweet pastry <input checked="" type="checkbox"/> Custard (105) <input type="checkbox"/> Chocolate bar <input type="checkbox"/> Sweets (not chocolate)	<input type="checkbox"/> Fizzy drink <input type="checkbox"/> Diet fizzy drink <input checked="" type="checkbox"/> Water Others (139) <u>Stuffing, Sageroma</u> <u>Sweet Beans (102)</u> <u>Ham</u> <u>10314, wt=34g</u>
2.01pm - 4.00pm Time slot 4	<input type="checkbox"/> White bread or toast <input type="checkbox"/> Margarine <input type="checkbox"/> Butter <input checked="" type="checkbox"/> Apple <input checked="" type="checkbox"/> Banana <input checked="" type="checkbox"/> Pear <input type="checkbox"/> Tangerine, mandarin, satsuma <input type="checkbox"/> Crisps or savoury snacks	<input type="checkbox"/> Biscuits—not chocolate <input type="checkbox"/> Biscuits—chocolate <input type="checkbox"/> Chocolate bar <input checked="" type="checkbox"/> Chocolate sweets* <input type="checkbox"/> Sweets (not chocolate) <input type="checkbox"/> Ice lolly <input type="checkbox"/> Cheese <input type="checkbox"/> Tomato ketchup	<input type="checkbox"/> Yoghurt / Fromage frais <input type="checkbox"/> Orange juice, unsweetened <input type="checkbox"/> Milk, full-fat drink <input type="checkbox"/> Milk, semi-skimmed drink <input type="checkbox"/> Squash—reduced sugar <input type="checkbox"/> Squash <input type="checkbox"/> Fizzy drink	<input type="checkbox"/> Diet fizzy drink <input type="checkbox"/> Water Others <u>mint</u> <u>SF chocolate</u> <u>sweets</u>
4.01pm - 7.00pm Time slot 5	<input type="checkbox"/> White bread or toast <input type="checkbox"/> Margarine <input type="checkbox"/> Butter <input type="checkbox"/> Apple <input type="checkbox"/> Banana <input type="checkbox"/> Grapes <input type="checkbox"/> Strawberries <input type="checkbox"/> Oven chips <input checked="" type="checkbox"/> Chips—fried <input type="checkbox"/> Boiled potatoes <input type="checkbox"/> Potatoes—other <input type="checkbox"/> Carrots <input type="checkbox"/> Peas <input type="checkbox"/> Sweetcorn <input type="checkbox"/> Cucumber	<input checked="" type="checkbox"/> Tomato <input type="checkbox"/> Broccoli <input type="checkbox"/> Sausages <input type="checkbox"/> Pasta, boiled <input type="checkbox"/> Pasta, tinned in tomato sauce <input type="checkbox"/> Fish fingers <input type="checkbox"/> Chicken or turkey nuggets <input type="checkbox"/> Chicken or turkey (not nuggets) <input type="checkbox"/> Pizza <input type="checkbox"/> Baked beans <input type="checkbox"/> Cheese <input type="checkbox"/> Boiled rice <input type="checkbox"/> Ham <input type="checkbox"/> Chapatti <input type="checkbox"/> Dhal	<input checked="" type="checkbox"/> Gravy <input type="checkbox"/> Tomato ketchup <input type="checkbox"/> Yoghurt / fromage frais <input type="checkbox"/> Crisps or savoury snacks <input type="checkbox"/> Biscuits—not chocolate <input type="checkbox"/> Biscuits—chocolate <input type="checkbox"/> Cake or sweet pastry <input type="checkbox"/> Chocolate bar <input type="checkbox"/> Chocolate sweets <input type="checkbox"/> Sweets (not chocolate) <input type="checkbox"/> Ice cream	<input type="checkbox"/> Milk, semi-skimmed drink <input type="checkbox"/> Squash—reduced sugar <input type="checkbox"/> Squash <input type="checkbox"/> Fizzy drink <input type="checkbox"/> Diet fizzy drink <input type="checkbox"/> Tea with milk <input type="checkbox"/> Water Others <u>Hamburgers (100g)</u> <u>1930, wt=42g</u>
7.01pm - 11.00pm Time slot 6	<input type="checkbox"/> White bread or toast <input type="checkbox"/> Margarine <input type="checkbox"/> Butter <input type="checkbox"/> Jam <input type="checkbox"/> Apple <input type="checkbox"/> Banana <input type="checkbox"/> Tangerine, mandarin, satsuma <input type="checkbox"/> Oven chips <input type="checkbox"/> Chips—fried <input type="checkbox"/> Cheese	<input type="checkbox"/> Pasta, boiled <input type="checkbox"/> Boiled rice <input type="checkbox"/> Chapatti <input type="checkbox"/> Dhal <input type="checkbox"/> Tomato Ketchup <input type="checkbox"/> Crisps or savoury snacks <input checked="" type="checkbox"/> Biscuits—not chocolate <input checked="" type="checkbox"/> Sugar <input type="checkbox"/> Chocolate bar	<input type="checkbox"/> Chocolate sweets <input type="checkbox"/> Sweets (not chocolate) <input type="checkbox"/> Ice lollies <input type="checkbox"/> Yoghurt / fromage frais <input type="checkbox"/> Orange juice, unsweetened <input type="checkbox"/> Milk, full-fat drink <input type="checkbox"/> Milk, semi-skimmed drink <input type="checkbox"/> Drinking chocolate powder <input type="checkbox"/> Milk shake powder	<input type="checkbox"/> Squash—reduced sugar <input type="checkbox"/> Squash <input type="checkbox"/> Fizzy drinks <input type="checkbox"/> Diet fizzy drinks <input type="checkbox"/> Tea with milk <input type="checkbox"/> Water Others 1760, 108g <u>Coffee with milk</u>

Figure 5 Example page of a food diary used in the primary school children

4.4.2 Middle Schools

For two consecutive three-day periods (i.e. Thursday, Friday, Saturday and Sunday, Monday, Tuesday) approximately six months apart (see Figure 6; adapted from Hossack, 2009¹⁰⁶) children recorded the day, date and time when food or drink was consumed.

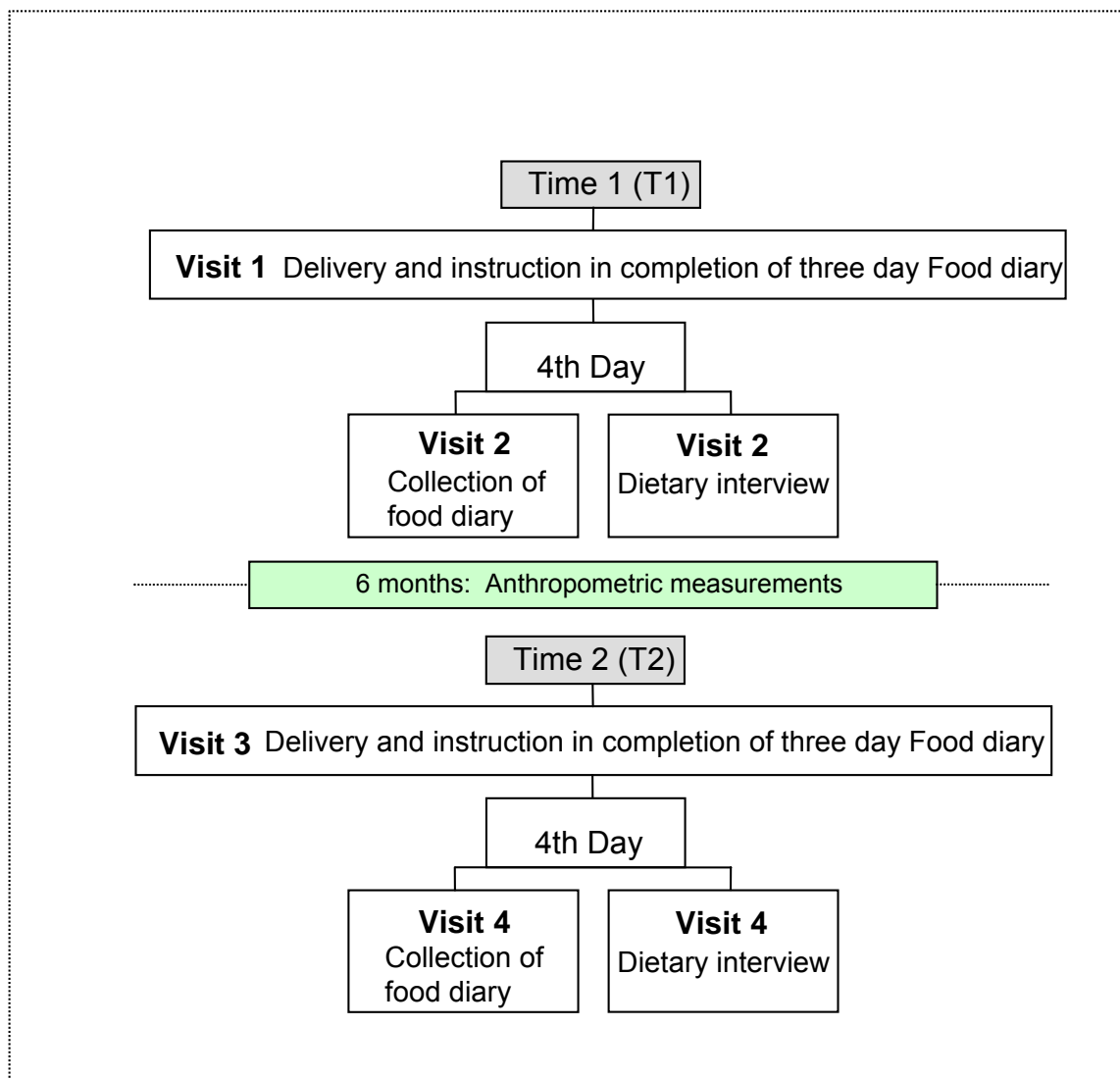


Figure 6 Process for dietary data collection in middle schools

Children also recorded a description of the food/drink item and amount consumed. Prior to commencing, participating children received verbal instructions on how to complete the food diary. An example page with instructions was included in the food diary to allow children to refer to it if required (see Figure 7). Food diaries were designed to be pocket size; the front cover included the child's ID and dates for completing. Each child received an appointment to return on the fourth day for an interview with myself to clarify the information recorded and estimate the portion size consumed using food models and a photographic food atlas for 11-14yolds (Figure 8 shows the food models used).¹⁰⁷ This method has been described in detail^{42, 102-104} and validated in previous Northumberland studies.^{101, 108} The food diary and method used

allowed foods to be categorised into 'school lunch', 'home-packed lunch' and 'food consumed outside of school hours'. Section 4.5 discusses the procedure for dietary data coding. See Appendix H for a full image of the dietary data collection tool used in the middle schools.

Day Wed PLEASE LEAVE THIS SECTION BLANK
 Date 21/11/2016 CHILD ID: TYPE OF DAY: School
Bed @ 10:30pm SURVEY: 12 DAY OF WEEK:
 LUNCH CODE: S/P/H/O Packed lunch

Time	Food or Drink	Amount Eaten	Office use		
			Place of purchase	Code	Weight
① 7.00	<u>milk</u> Coco Pops		H	L2 201 (C) L1 2 Bisc (M)	
② 8.30	Energy drink		shop	300mls	
③ 10.50	Chips <u>Baked</u>		shop	x1 pack	
④ 12.00	Sandwich		PL	see below	
12.00	drink (Apple juice)		PL	see below	
12.00	Biscuit		PL	Breakaway	
⑤ 4.00	Orange juice <u>- Ripe</u>		H	L3 Glass	
⑥ 6.00	Pizza and chips <u>thick cut frozen</u>		H	chips x10 Pizza 205 #1A	
7.00	Ice cream <u>vanilla</u>		H	x1	
⑦ 8.30	Biscuit <u>rain</u>		H	6 bisc 11 x1	
⑧ 12.00	Cheese - cheddar		PL	CH 26 x 3	
	Ham		PL	HOM x1 slice	
	Brown bread		PL	BR 46 x 2	
	butte - can't believe not butte		PL	Pic 702 x 2	
⑨ 6pm	water (tap)		H	L3 Glass	

Office use		
Place of purchase	Code	Weight
Coco Pops	11488	37g
Milk	12313	161g
Energy drink	21051	300g
Chips	17445	25g
See below		
Apple Juice	12271	227g
Biscuit	11526	20g
Juice	14301	200g
Chips	13030	160g
Pizza	21527	90g
Ice Cream	12587	60g
Biscuit	11513	15g
Cheese	12134	78g
Ham	1958	23g
Bread	11456	92g
Butter	17022	8g
Water	17377	200g

Figure 7 Example page of a food diary used in the middle school children



Figure 8 Food models used in the dietary data collection in middle schools

4.5 Portion size and dietary data coding

Primary schools

FAST assesses foods within six defined daily time slots, along with age- and sex-specific portion sizes, derived from the National Diet and Nutrition Surveys (NDNS).⁶ Each of the six defined time slots contained two sections for recording dietary intake (see Figure 5):

- i. a pre-printed tick list of foods most commonly consumed by children aged 4-7y in each of the six timeslots as derived from the NDNS referred to as 'standard foods'
- ii. a facility to record foods not listed referred to as 'other foods'

Portion sizes for foods recorded as 'other foods' were determined retrospectively from NDNS data and work by Wrieden *et al*, 2008¹⁰⁹ For these foods portion sizes were not age and sex-specific but were an average for 4-7y olds.

Middle schools

Food weight consumed was calculated from the food models and food photographs¹⁰⁷ as noted in section 4.4.2.

Primary and middle schools

All dietary coding for nutritional composition was based on McCance and Widdowson's Integrated Composition of Food Dataset.¹¹⁰ This dataset was incorporated into a Microsoft (MS) ACCESS relational database used for all data storage and analysis of food and nutrient intake. Occasionally for some foods where no matching food composition code was available a product search was conducted using the three main supermarkets. This allowed nutritional information to be obtained and subsequently the food composition code best matching the nutritional composition of the food item recorded was used.

School recipes and menus were obtained to allow for coding of school food. The nutritional composition information was incorporated in the MS ACCESS relational database. If school recipes were not available foods were coded using McCance and Widdowson's Integrated Composition of Food Dataset.¹¹⁰

4.6 Data processing and handling

Primary and middle schools

4.6.1 Data entry

All data were entered onto separate but identical purpose-built ACCESS relational databases; one for each survey. Each child's information was recorded at an individual level. Databases were password protected for security; diaries were stored according to University policy and regulations.

4.6.2 Data checking

Primary and middle schools

A number of procedures were adopted to ensure consistency of food coding across the datasets:

- i. a Microsoft Excel spreadsheet was created at the start of dietary coding containing all food codes used/allocated to foods. This was referred to frequently to ensure the same food code was allocated for these foods in individual diaries and across the databases (this was applicable to 'other foods' in primary school children and all foods in middle school children)
- ii. on completion the dietary coding an output of all food codes, weights and food groups allocated across the datasets were exported and interrogated. This enabled consistency to be checked; any inconsistencies were identified and changes were made to relevant individuals across the datasets (this was applicable to 'other foods' in primary school children and all foods in middle school children).

4.7 Socio-economic status

Socio-economic status was estimated using the English Index of Multiple Deprivation (IMD) 2007,¹¹¹ allocated using individual children's postcodes. IMD is calculated at lower layer super output areas in England and provides a single deprivation score based on seven domains: income, employment, health and disability, education, skills and training, barriers to housing and services, crime and living environment.¹¹¹ The IMD categorisation is discussed in the method section of Papers I, III and IV, as a slightly different approach was taken in primary and middle schools.

4.8 Statistical analysis

The sample size of the study was pragmatic and determined by the number of children in the participating schools, and by the number of these schools prepared to participate in the survey. However, in the earlier surveys with children aged 11-12 years and using the same method of recruitment, important and statistically significant changes in selected macro- and micronutrients were identified.¹⁰³⁻¹⁰⁵ The approach for the statistical analysis was determined by the key aims and questions of the individual papers (addressed in section 3.7); the analysis used is discussed under sub-headings below.

Method of consent, completion rates and dietary data quality [Paper I]

Four logistic regressions were performed. In each, a binary outcome was related to factors indicating IMD quintile, the method of obtaining consent, and the

interaction of these factors, all adjusted for gender. The outcome in the first analysis was whether or not each eligible child's parent gave consent to be in the study. In the second, the outcome was whether or not each eligible child provided a complete dietary diary. These analyses give estimates of the probability of giving consent and of the probability providing a complete dietary diary, respectively. The third analysis also considered whether or not a child completed their dietary diary but only amongst children who agreed to participate in the study: this gives an estimate of the conditional probability a child provides a complete diary, given that they have agreed to participate in the study. The outcome in the final analysis considered data quality, that is whether or not children providing diaries were classified as an under-reporter or not.

Children's mean nutrient intake at lunchtime and in total diet [Papers II & III]

The analysis assessed the direct effect of changes in school lunch standards, and in Paper II considered only children who ate school lunches. The mean intake of macro- and micronutrients of each child from this source alone were compared between the 2003-2004 and 2008-2009 surveys. The analysis presented in Paper III examined the change at lunchtime in children's mean macro and micronutrient intake from a school or home-packed lunch between 1999-2000 and 2009-2010.

A more detailed analysis in both papers using a linear mixed effect model considered the intake of macro and micronutrients from the total diet: this analysis explored the year of the survey, whether the child ate a school or home-packed lunch, and the interaction between these factors. All analyses adjusted for the effect of gender, with year (of survey), and lunch type (school or home-packed lunch) taken as fixed effects: potential correlation between responses on children within the same school and also within children were accommodated by fitting random effects for school and child. The models were fitted using `xtmixed` in Stata (version 11) and `lme` in R (version 2.14.0). Vitamin C was log transformed for analysis and for this variable geometric means and ratios were reported.

Children's mean nutrient intake and the effect of level of deprivation at lunchtime and in total diet [Papers III & IV]

The analysis examined the change in children's mean macro and micronutrient intakes at lunchtime and in total diet across the socio-economic spectrum. A similar approach to that discussed above was used. Using a linear mixed effect model this analysis considered the effect of year, whether a child ate a school or home-packed lunch, level of deprivation and the interaction(s) between these factors (i.e. year by lunch type, year by level of deprivation, lunch type by level of deprivation and the three-way interaction year by lunch type by level of deprivation). All analyses adjusted for the effect of gender. Potential correlation between responses on children within the same school or within children was accommodated by fitting random effects for each. The models were fitted using xtmixed in STATA (version 11) and 'lme' in R (version 2.14.0).

The effect of the introduction of food and nutrient-based standards on school lunch take-up [Papers III & IV]

A linear model was fitted directly to the proportion of children taking school lunch using maximum likelihood (fitted in R using optim), which allowed for differences between IMD quintiles, between years and their interaction. The linear model allowed a more natural interpretation than would have been possible with a logistic model.

4.9 Paper I: Does the use of passive or active consent affect consent or completion rates, or dietary data quality? Repeat cross-sectional survey among school children aged 11-12 years

BMJ Open Does the use of passive or active consent affect consent or completion rates, or dietary data quality? Repeat cross-sectional survey among school children aged 11–12 years

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ABSTRACT

Objectives: An expectation of research is that participants should give fully informed consent. However, there is also a need to maximise recruitment to ensure representativeness. We explored the impact of passive or active parental consent on consent, completion rates and on dietary data quality in a survey among children aged 11–12 years.

Setting: Six middle schools in North-East England.

Participants: All children aged 11–12 years attending the six middle schools were eligible to participate (n=1141).

Main outcomes: Primary outcomes: whether or not each eligible child's parent gave consent and provided a complete dietary diary; whether or not a child completed their dietary diary but only among children who agreed to participate, and whether or not children providing diaries were classified as an under-reporter or not.

Results: Parents were more likely to consent passively than actively. This difference was greater among the more deprived: OR 16.9 (95% CI 5.7 to 50.2) in the least and 129.6 (95% CI 39.9 to 420.6) in the most deprived quintile (test for interaction: method of consent by level of deprivation, p=0.02). For all children eligible, completion was more likely if passive consent was used (OR 2.8, 95% CI 2.2 to 3.7). When only children who gave consent are considered, completion was less likely when passive rather than active consent was used (OR 0.6, 95% CI 0.4 to 0.9). Completion rate decreased as level of deprivation increased; we found no evidence that the OR for the method of consent varied by level of deprivation. There was no evidence that the quality of dietary data, as measured by an assessment of under-reporting, differed by method of consent (OR 0.8, 95% CI 0.5 to 1.2).

Conclusions: Passive consent led to a higher participation rate and a more representative sample without compromising data quality.

INTRODUCTION

A central tenet of health and social research is that no one should be recruited to a study without providing informed consent. When

Strengths and limitations of this study

- We have shown that using passive consent can lead to a higher participation rate and a more representative sample.
- Data quality was not compromised.
- In some circumstances passive consent may offer an ethical alternative to active consent ensuring that all children have an equal opportunity to participate in research.
- It is possible that the differences are due to differences between the two academic years: 2007–2008 and 2009–2010 as the method of consent used was almost totally confounded with year.

the research involves children, the situation is further complicated by the need to obtain consent from the child's legal guardian. While the main concern is that recruits should be fully informed and free to make their choice, all researchers are conscious of the effect of a low recruitment rate on the representativeness of the sample obtained^{1 2} and thus the generalisability of findings. In any particular context, there may be several equally acceptable ways by which consent may be obtained. If the proportion of those approached who agree to participate varies with the method used, then this is likely to have implications for the usefulness of the inferences that are ultimately made.

We report two dietary surveys of children aged 11–12 years where consent was obtained using two methods: 'passive' and 'active'. For both methods a letter containing information about the study was sent to the child's parent or guardian (parent used throughout) via their school. When passive consent was used the parent was required to return a signed form only if they did not want their

child to participate, while for active consent a signed form had to be returned giving permission for their child to participate. The use of active consent has some limitations. Letters sent from school are less likely to be returned from children in more deprived areas,³ thereby inducing a socioeconomic bias in the sample obtained, while parental apathy^{3 4} reduces participation rates. Monaghan *et al*³ and Mellor *et al*⁵ showed that parents excluded their child if the research focused on a topic they were currently encountering, for example, dental caries or overweight/obesity. These factors led to low participation rates and biased samples.^{3 6 7} Passive consent has the potential to address these issues by increasing participation and including individuals who may otherwise not participate. However, it is important that the data obtained are not of poorer quality. This is particularly relevant for dietary surveys: larger numbers of participants are advantageous only if records are completed. To our knowledge, there is no research that examines the effect of passive or active consent on dietary data quality. This paper uses data from two cross-sectional surveys in 11–12 year-olds to explore the effect of passive or active consent across the socioeconomic spectrum on the percentage of children for whom consent was given, who on go to complete dietary diaries and also on the quality of the data that they provide.

METHODS

Study design and recruitment

We used data from two cross-sectional surveys that formed part of a series of dietary surveys in middle schools in Northumberland, North-east England.^{8–11} In 2007–2008 and 2009–2010, schools were invited to participate by letter, followed by a presentation at each school. Following the presentation each child was given a parental information letter to take to parents which included information on the study, consent and a form for return to school. In 2007–2008, parents were asked to return the form if they wished their child to participate. In 2009–2010, during preparatory discussions with head teachers it was suggested the consent method should be changed from active to passive. The rationale given by head teachers was that by using active consent we were in effect excluding children whose parents routinely failed to return forms sent by schools as well as children whose parents actively did not wish their child to participate. After obtaining documented support from head teachers and school governors, Newcastle University Ethics Committee granted permission for passive consent to be used in this study (reference 00011/2009). Therefore, in 2009–2010, the consent letter sent to schools asked parents to return the form only if they did not wish their child to participate. There was one exception to this; the head teacher of the smallest school preferred to continue to use active consent: data from this school have been retained in the following analysis. In both surveys, children were able to exclude themselves by

not completing the food diaries or by refusing to have anthropometric measurements taken and were free to withdraw from the study at any time.

Categorising socioeconomic status and under-reporting

Socioeconomic status

Anonymised full (7 digit) postcodes were obtained for all eligible children; participating children provided individual postcodes. Socioeconomic status was estimated using the English Index of Multiple Deprivation (IMD) 2007,¹² matched to individual children's postcodes. IMD is based on lower layer super output areas in England and provides a single deprivation score based on seven domains: income, employment, health and disability, education, skills and training, barriers to housing and services, crime and living environment.¹² This allows areas to be ranked by level of deprivation.¹² IMD scores were categorised into quintiles relative to national data: quintile 1 included children living in the 20% least deprived area and quintile 5 included children living in the 20% most deprived areas.

Under-reporting

Likely under-reporting was used as a marker of data quality in this study. Dietary data collected were assessed by comparing the child's mean 6-day energy intake (2×3 days; EI) with the predicted basal metabolic rate (BMR). The ratio EI:BMR was used to estimate the number of likely under-reporters; we used values below 1.1 to identify under-reporters. The methods of calculating BMR,¹³ and the cut-off for identifying 'under-reporters' were those used in a previous Northumberland study.¹⁰

Statistical analysis

Four logistic regressions were performed. In each, a binary outcome was related to factors indicating IMD quintile, the method of obtaining consent and the interaction of these factors, all adjusted for gender. The outcome in the first analysis was whether or not each eligible child's parent gave consent to be in the study. In the second, the outcome was whether or not each eligible child provided a complete dietary diary. These analyses give estimates of the probability of giving consent and of the probability of providing a complete dietary diary, respectively. The third analysis also considered whether or not a child completed their dietary diary but only among children who agreed to participate in the study: this gives an estimate of the conditional probability that a child provided a complete diary, given that they agreed to participate in the study. The outcome in the final analysis considered data quality, that is, whether or not children providing diaries were classified as an under-reporter or not.

Tests of main effects and interactions are reported along with appropriate ORs and 95% CIs. All analyses were conducted in R (V.2.14.0) and STATA V.11.

Ethics

The amendment to the method of consent from active to passive was granted by Newcastle University Ethics Committee (reference 00011/2009).

RESULTS

Table 1 shows the number (percentage) of all eligible children for who consent was given (parental), and who completed by method of consent and level of deprivation. Tables 2 and 3 present the ORs and 95% CI for the method of consent, level of deprivation and the interaction (method of consent by level of deprivation) relevant to the outcomes. Table 4 presents the ORs and 95% CI for the method of consent and level of deprivation in children who under-reported.

All eligible children

We found a higher percentage of children's parents consented using passive (96%) compared with active consent (41%). With passive consent a similar percentage of children's parents consented in each deprivation quintile, whereas when active consent was used the consent rate decreased as level of deprivation increased (table 1). We found evidence of an interaction between the method of consent and level of deprivation for the proportion of children's parents that consented ($p=0.023$). When using passive consent, children's parents in IMD quintile 1 (least deprived) were 16.9 times more likely to consent than when using active consent in IMD quintile 1 (OR 16.9, 95% CI 5.7 to 50.2), while in IMD quintile 5 (most deprived) this value rose to 129.6 (95% CI 39.9 to 420.6; table 2).

The method of consent also affected the percentage of children who completed their dietary diaries. A higher percentage of children completed their dietary diaries when consented using passive (53%) compared with active consent (29%; table 1; OR 2.8 (95% CI 2.2 to 3.7; $p<0.001$). Although there was no evidence that the effect of the method of consent changed with the level of deprivation (test for interaction, $p=0.73$), there was strong

evidence that the chance of completing decreased with increasing level of deprivation, with a strong linear trend across the quintiles ($p<0.001$ for linear trend, $p=0.37$ for non-linearity; see table 3 for estimates of the ORs).

Only children for whom consent was given

For those children whose parents gave consent the percentage completing was lower for passive (55%) compared with active consent (69%; OR 0.6, 95% CI 0.4 to 0.9, $p=0.004$). Again, there was no evidence that the effect of the method of consent varied with level of deprivation ($p=0.99$), but there was strong evidence that the chance of completing decreased with increasing level of deprivation ($p<0.001$ for linear trend, $p=0.21$ for non-linearity). Children in IMD quintile 2 were 0.5 times as likely to complete as children in IMD quintile 1 (least deprived; 95% CI 0.3 to 0.8, $p=0.01$); with children in IMD quintile 5 (most deprived) being 0.2 times as likely to complete as children in IMD quintile 1 (95% CI 0.1 to 0.3, $p<0.001$; table 3).

We found no evidence that under-reporting was affected by the method of consent (OR 0.8, 95% CI 0.5 to 1.2, $p=0.28$). There was marginal evidence that under-reporting was more likely in the most deprived quintile; children in the most deprived quintile were 0.6 times as likely to under-report as children in the least deprived quintile (95% CI 0.3 to 1.0, $p=0.05$; see table 4 for estimates of the ORs).

DISCUSSION

We found that parents were more likely to consent using passive compared with active consent. The size of the effect of the change in method (active to passive) was greater in more deprived groups. The method of consent also affected the percentage of children who completed: use of passive consent gave a higher completion rate. In contrast, when only children for whom consent was obtained were considered, those children whose parents had actively consented were more likely to complete than children whose parents had passively

Table 1 Number (percentage) of children who consented* and completed by method of consent and level of deprivation

	Method of consent							
	Passive				Active			
	All eligible n	Consented n (%)	Completed n (%)	Completed as percentage of consented %	All Eligible n	Consented n (%)	Completed n (%)	Completed as percentage of consented %
Total	502	484 (96)	268 (53)	55	639	264 (41)	183 (29)	69
IMD quintile								
1 (least deprived)	95	91 (96)	70 (74)	77	91	52 (57)	44 (48)	85
2	83	78 (94)	50 (60)	64	102	49 (48)	35 (34)	71
3	66	63 (95)	41 (62)	65	86	36 (42)	28 (33)	78
4	73	70 (96)	34 (47)	49	121	52 (43)	34 (28)	65
5 (most deprived)	185	182 (98)	73 (39)	40	239	75 (31)	42 (18)	56

*Parental consent.

IMD, Index of Multiple Deprivation.

Table 2 Consent: number (percentage) of all eligible children with OR and 95% CI for method of consent and level of deprivation interaction

	Method of consent				OR (95% CI)*
	Passive		Active		
	All eligible n	Consented n (%)	All eligible n	Consented n (%)	
Total	502	484 (96)	639	264 (41)	–
IMD quintile					
1 (least deprived)	95	91 (96)	91	52 (57)	16.9 (5.7 to 50.2)
2	83	78 (94)	102	49 (48)	14.0 (5.2 to 37.9)
3	66	63 (95)	86	36 (42)	39.2 (8.9 to 172.0)
4	73	70 (96)	121	52 (43)	25.6 (7.6 to 86.7)
5 (most deprived)	185	182 (98)	239	75 (31)	129.6 (39.9 to 420.6)

*p Value for interaction: method of consent by level of deprivation $p=0.023$ (adjusted for gender).
IMD, Index of Multiple Deprivation.

consented. Nevertheless, the final completion rate was higher when passive consent was used. Although the chance of completing decreased with increasing level of deprivation, we found no evidence that the OR for the effect of the method of consent varied with the level of deprivation. We found no evidence that the quality of data, as measured by assessment of under-reporting, differed between the methods of consent.

A strength of this study is that we were able to explore the use of two different consent methods in the same six schools as a result of a poor consent rate in a dietary survey in 2007–2008, and after discussions with head teachers of schools who expressed the opinion that we were excluding children by using active consent. A limitation is our classification of socioeconomic status. Socioeconomic status was estimated using the Index of Multiple Deprivation, which does not measure individual levels of deprivation, and may lead to misclassification bias.¹⁴ In this study we assumed that the differences were due to the methods of consent. As the method of consent used was

almost totally confounded with year it is possible that the differences are due to differences between the two academic years: 2007–2008 and 2009–2010; however, one school continued to use the same method of consent in both 2007–2008 and 2009–2010 with a slight fall in participation, highlighting the effect of the method of consent. In addition, the main outcome of interest was to examine the effect of the method of consent used on the percentage of children for whom consent was given, adequately completed their dietary data, and on the quality of data provided. Our study found the use of active consent to be associated with lower participation, a finding previously reported, though not previously in school-based dietary studies.^{2, 7, 15} For example, in a smoking prevention study, by changing the method of consent from active to passive, non-participation reduced by 36%.²

There is an opinion that passive consent should be advocated for research where there is low risk to participants.¹ The UN convention on the Rights of the Child advocates that a child should be involved in decisions and their opinions should be taken into account when adults are making decisions that affect them.¹⁶ This consideration should also be respected in research, irrespective of the method of consent; research involving children needs to make clear that: participation is voluntary;¹⁷ there should be no pressure to participate;⁶ they can change their mind⁶ and leave the study at any point.¹⁷ If these are made clear to children from the outset of the study, our findings support the use of passive consent in dietary surveys to obtain a higher participation rate, and a more representative sample, without compromising data quality. The implications regarding the use of passive consent in this study relate specifically to dietary surveys. There is potential that passive consent is applicable to other areas of research and settings (ie, the school environment). However, regardless of the type of research or setting the factors noted above need to be adhered to. A high participation rate and a representative sample are paramount to research; our findings show that the use of passive consent helps achieve this. Passive consent led to a

Table 3 Completion: OR and 95% CI for method of consent and level of deprivation (relative to least deprived) in all eligible children and children for who consent was given

Method	Completed	
	All eligible* OR (95% CI)‡	Consented†
Passive relative to active	2.8 (2.2 to 3.7)	0.6 (0.4 to 0.9)
IMD quintile		
1 (least deprived)	–	–
2	0.6 (0.4 to 0.9)	0.5 (0.3 to 0.8)
3	0.6 (0.4 to 0.9)	0.6 (0.3 to 1.1)
4	0.3 (0.2 to 0.5)	0.3 (0.1 to 0.5)
5 (most deprived)	0.2 (0.1 to 0.3)	0.2 (0.1 to 0.3)

* $p < 0.001$ for linear trend; $p = 0.37$ for non-linearity.
† $p < 0.001$ for linear trend; $p = 0.21$ for non-linearity.
‡Adjusted for gender.

Table 4 Under-reporting: number (percentage) of children with OR and 95% CI for method of consent and level of deprivation

	Method of consent				OR (95% CI)*
	Passive		Active		
	Completed n	Under-reporters† n (%)	Completed n	Under-reporters n (%)	
Total	257‡	116 (45)	167‡	65 (39)	0.8 (0.5 to 1.2)
IMD quintile					
1 (least deprived)	69	29 (42)	43	18 (42)	–
2	48	19 (40)	31	9 (29)	1.3 (0.7 to 2.4)
3	36	13 (36)	26	7 (27)	1.5 (0.8 to 2.9)
4	31	13 (42)	30	12 (40)	1.0 (0.5 to 2.0)
5 (most deprived)	73	42 (58)	37	19 (51)	0.6 (0.3 to 1.0)

*Adjusted for gender; OR passive relative to active and level of deprivation relative to least deprived.

†The ratio EI: BMR was used to estimate the number of likely under-reporters; we used values below 1.1 to identify under-reporters as used in previous Northumberland surveys.^{10–13}

‡No weight/height information in passive (n=11) and active consent (n=16).

BMR, basal metabolic rate; EI, energy intake; IMD, Index of Multiple Deprivation.

higher participation rate and a more representative sample without compromising data quality.

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Contributors AJA conceived the research and with MW and SS designed the study. SS, Jennifer Delve and Alison Hossack collected the data. SS and JNSM conducted the analyses. SS drafted the manuscript and all authors commented on drafts and approved the final version. AJA is the study guarantor.

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REFERENCES

1. Junghans C, Feder G, Hemingway H, *et al*. Recruiting patients to medical research: double blind randomised trial of 'opt-in' versus 'opt-out' strategies. *BMJ* 2005;331:940.
2. Severson H, Ary D. Sampling bias due to consent procedures with adolescents. *Addict Behav* 1983;8:433–7.
3. Monaghan N, Jones S, Morgan M. Do parents of children with caries choose to opt-out of positive consent dental surveys in Wales? *Br Dent J* 2011;210:E1.
4. Dent C, Galaif J, Sussman S, *et al*. Demographic, psychosocial and behavioral differences in samples of actively and passively consented adolescents. *Addict Behav* 1993;18:51–6.
5. Mellor J, Rapoport R, Maliniak D. The impact of child obesity on active parental consent in school-based survey research on healthy eating and physical activity. *Eval Rev* 2008;32:298–312.
6. O'Neill O. Some limits of informed consent. *J Med Ethics* 2003;29:4–7.
7. Lacy K, Kremer P, de Silva-Sanigorski A, *et al*. The appropriateness of opt-out consent for monitoring childhood obesity in Australia. *Pediatr Obes* 2012;7:e62–7.
8. Adamson AJ, Rugg-Gunn AJ, Butler TJ, *et al*. Nutritional intake, height and weight of 11–12-year-old Northumbrian children in 1990 compared with information obtained in 1980. *Br J Nutr* 1992;68:543–63.
9. Adamson AJ, Rugg-Gunn AJ, Butler TJ, *et al*. The contribution of foods from outside the home to the nutrient intake of young adolescents. *J Hum Nutr Diet* 1996;9:55–68.
10. Fletcher ES, Rugg-Gunn AJ, Matthews JN, *et al*. Changes over 20 years in macronutrient intake and body mass index in 11- to 12-year old adolescents living in Northumberland. *Br J Nutr* 2004;92:321–33.
11. Rugg-Gunn AJ, Fletcher ES, Matthews JN, *et al*. Changes in consumption of sugars by English adolescents over 20 years. *Public Health Nutr* 2007;10:354–63.
12. Communities and Local Government Indices of Deprivation. 2007. <http://webarchive.nationalarchives.gov.uk/+http://www.communities.gov.uk/communities/neighbourhoodrenewal/deprivation/deprivation07/> (accessed 30 Jun 2011).
13. Schofield WN. Predicting basal metabolic rate, new standards and review of previous work. *Hum Nutr Clin Nutr* 1985;39(Suppl 1):5–41.
14. Pockett R, Adlard N, Carroll S, *et al*. Paediatric hospital admissions for rotavirus gastroenteritis and infectious gastroenteritis of all causes in England: an analysis of correlation with deprivation. *Curr Med Res Opin* 2011;27:777–84.
15. Nellist K, Coats K, Friedrichs M. Using a representative sample of elementary school students to determine the statewide prevalence of childhood overweight and obesity in Utah. *Prev Chronic Dis* 2009;6:A136.
16. UNICEF The UN Conventions on the Rights of the Child. http://www.unicef.org/crc/files/Rights_overview.pdf (accessed 23 Sep 2014).
17. Ross J, Sundberg E, Flint K. Informed consent in school health research: why, how and making it easy. *J Sch Health* 1999;69:171–6.

Chapter 5 Results of the impact of school food standards on children's diets

Chapter overview:

This chapter provides a summary of the key dietary findings addressed in the three research questions:

- *Research question 1:* Did the introduction of food and nutrient-based standards impact on lunchtime and total dietary intake in children aged 4-7y and 11-12y? [Papers II & III]
- *Research question 2:* Did the introduction of nutritional standards for school lunches have an equitable impact on children's diets across the socio-economic spectrum? [Papers III & IV]
- *Research question 3:* Did school lunch take-up change across the socio-economic spectrum following the introduction of food and nutrient-based standards? [Papers III & IV]

The respective papers are inserted at the end; Paper II in section 5.2, Paper III in section 5.3, and Paper IV in section 5.4.

5.1 Key findings on the impact of school food standards on children's mean dietary intake (4-7y and 11-12y olds)

Research question 1: *Did the introduction of food and nutrient-based standards impact on lunchtime and total dietary intake in children aged 4-7y and 11-12y?* (Paper II and III)

Research question 3: *Did school lunch take-up change across the socio-economic spectrum following the introduction of food and nutrient-based standards?* (Paper II, III and IV)

Table 13 provides a summary of the key findings included in Papers II, III and IV. These papers evaluated the impact of implementing food and nutrient-based standards on children's mean nutrient intake at lunchtime and in total diet.

School lunch take-up is reported in Paper III and IV. Table 13 also presents the results on school lunch take-up.

Table 13 Key findings on the impact of implementing school food standards on children's mean nutrient intake at lunchtime and in total diet by age

	Age	
	4-7y <i>n</i> =407 (2003-2004) <i>n</i> =641 (2008-2009)	11-12y <i>n</i> =298 (1999-2000) <i>n</i> =215 (2009-2010)
Lunchtime (school lunch)	Post-policy implementation there were reductions in per cent energy from fat ($p<0.001$), saturated fat ($p<0.001$), NMES ($p<0.001$) and absolute amounts of sodium ($p<0.001$), and increases in micronutrients, such as calcium ($p<0.001$), vitamin C ($p<0.001$) and iron ($p<0.001$)	Post-policy implementation there were reductions in per cent energy from fat ($p<0.001$) saturated fat ($p<0.001$) and absolute amounts of sodium ($p<0.001$), but also, a decrease in NSP ($p<0.001$) and iron ($p<0.001$)
Total diet	Post-policy implementation a child who ate a school lunch had a lower per cent energy from fat (compared to higher pre-policy), and increases in nutrients, such as protein, NSP and vitamin C) compared with children who ate a home-packed lunch. These year and lunch type interactions were all found to be statistically significant: per cent from fat ($p<0.001$); protein ($p=0.04$); NSP ($p=0.001$) and vitamin C ($p<0.001$)	Per cent energy from fat was the only nutrient where a year and lunch type interaction was found ($p<0.001$)
School lunch take-up	Decreased from 60% to 51% post-policy implementation	Decreased from 81% to 36% post-policy implementation

The findings at lunchtime in both 4-7y and 11-12y olds show improvements in mean intakes of some nutrients post-policy implementation. For children aged

11-12y there was evidence of a decrease in certain key micronutrients which was not observed in primary school children (see Table 13). In the 4-7y olds, the changes at lunchtime post-policy implementation were also reflected in their total diet. There was limited evidence of this in the 11-12y olds. Potential explanations for these differences may be associated with a number of factors. The dietary data collection methods were different. In the 4-7y olds an observed four-day dietary data collection was used; trained observers completed these in schools and parents at home. The 11-12y old children completed a 2 X three-day food diary and a researcher-led interview. However, identical dietary data collection methods were used pre and post-policy implementation in both age groups. Children's food choices and the food available to choose both at lunchtime and outside of school may also explain differences. The younger children's food choices may have been guided more by dining staff whereas 11-12y olds exercise more independence in their food choices. At home, parents may have had more influence on the 4-7y olds dietary intake than on the 11-12y olds. Also, school lunch take-up decreased more in the 11-12y olds pre to post-policy implementation (81% to 36%) compared with the 4-7y olds (60% to 51%). The impact of changes to school lunch, however beneficial, have no effect on children who do not do not consume them.⁴⁸

There may be a number of reasons for this decrease and these are discussed in Paper III. To provide some short discussion one additional factor 'children's lunch type preference' is discussed here. In a study by Warren *et al*,¹¹² they found in children aged 10-11y there was a preference for home-packed lunch. This was associated with children having more freedom to choose the foods they wanted to eat in a home-packed lunch; for some parents they had little influence on the nutritional content of their child's home-packed lunch. The contents of the home-packed lunch were largely chosen by the child.¹¹² In contrast, the 7-8y olds preferred a school lunch as they could sit with friends and also leave foods. Whereas if they had a home-packed lunch they had to eat it.¹¹² This potentially highlights that different factors influence lunch type choices between younger and older children. Social factors also play an important role in children's food choice, for example, eating the same as a friend is considered more important than choosing a healthy option.^{113, 114} Other aspects are discussed in Paper III.

Research question 2: *Did the introduction of nutritional standards for school lunches have an equitable impact on children's diets across the socio-economic spectrum?*

Table 14 provides a summary of the key findings from the second research question stated above in the 4-7y and 11-12y old children. This is followed by a short discussion of the key findings. A small number of 4-7y olds were excluded in this analysis as no socio-economic information was available.

Table 14 Key findings on the equitable impact of implementing school food standards on children's mean nutrient intake at lunchtime and in total diet by age

	Age group	
	4-7y <i>n</i> = 368 (2003-2004) <i>n</i> = 624 (2008-2009)	11-12y <i>n</i> = 298 (1999-2000) <i>n</i> = 215 (2009-2010)
Lunchtime (school lunch)	<p>There was evidence of an increasing difference across deprivation groups in mean NSP, iron and zinc intakes regardless of lunch type (year and level of deprivation interaction: $p=0.001$; $p=0.004$ and $p=0.002$ respectively)</p> <p>Children in the most deprived groups were found to have a lower mean intakes of these nutrients</p>	<p>There was no evidence found that level of deprivation had an effect on mean nutrient intake</p>
Total diet	<p>Children in the most deprived quintile had a lower mean NSP, iron and zinc regardless of lunch type (year and level of deprivation interaction: $p=0.014$; $p=0.002$ and $p=0.007$ respectively).</p> <p>Year, lunch type and level of deprivation were found to influence children's mean per cent energy from NMES and vitamin C, and there was a widening difference by lunch type (year, lunch type and level of deprivation interaction: $p=0.047$ and $p=0.035$ respectively)</p>	<p>Children in the most deprived quintile had a lower mean vitamin C and calcium intake regardless of lunch type or year ($p<0.001$ and $p=0.04$ respectively)</p> <p>There was no evidence found of any 3-way interactions</p>

In the 4-7y olds, the findings at lunchtime showed there was evidence that by 2008-2009 children in the most deprived families had a lower mean micronutrient intake regardless of their lunch type. These findings were also reflected in children's total diet (see Table 14). In total diet, year, lunch type and level of deprivation were found to influence children's mean per cent energy from NMES and vitamin C (mg). For example, for children who consumed a school lunch, per cent energy from NMES reduced to similar levels for all the deprivation groups, thereby narrowing inequalities. While for children who consumed a home-packed lunch, the decrease was less marked in the least deprived group. This indicates school lunch may have some influence on addressing children's dietary inequalities. In the 11-12y olds, there was no evidence found of a difference across the deprivation groups in children's mean intakes at lunchtime. In total diet, there was some evidence that children in the most deprived quintile had a lower mean intake of micronutrients regardless of year or lunch type (see Table 14). In both age groups, children's per cent energy from saturated fat and NMES exceeded recommendations (DRVs) as did the absolute amounts of sodium. For the 11-12y olds, mean iron intake was below the RNI. This highlights that despite a major policy change to school food in England, there is still a need to address children's diets in both primary and middle school aged children. The papers present the full analysis and provide a detailed discussion.

5.2 Paper II The impact of food and nutrient-based standards on primary school children's lunch and total dietary intake: a natural experimental evaluation of government policy in England.

The Impact of Food and Nutrient-Based Standards on Primary School Children's Lunch and Total Dietary Intake: A Natural Experimental Evaluation of Government Policy in England

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Abstract

In 2005, the nutritional content of children's school lunches in England was widely criticised, leading to a major policy change in 2006. Food and nutrient-based standards were reintroduced requiring primary schools to comply by September 2008. We aimed to determine the effect of the policy on the nutritional content at lunchtime and in children's total diet. We undertook a natural experimental evaluation, analysing data from cross-sectional surveys in 12 primary schools in North East England, pre and post policy. Dietary data were collected on four consecutive days from children aged 4–7 years ($n = 385$ in 2003–4; $n = 632$ in 2008–9). We used linear mixed effect models to analyse the effects of gender, year, and lunch type on children's mean total daily intake. Both pre- and post-implementation, children who ate a school lunch consumed less sodium (mean change -128 mg, 95% CI: -183 to -73 mg) in their total diet than children eating home-packed lunches. Post-implementation, children eating school lunches consumed a lower % energy from fat (-1.8% , -2.8 to -0.9) and saturated fat (-1.0% ; -1.6 to -0.5) than children eating packed lunches. Children eating school lunches post implementation consumed significantly more carbohydrate (16.4 g, 5.3 to 27.6), protein (3.6 g, 1.1 to 6.0), non-starch polysaccharides (1.5 g, 0.5 to 1.9), vitamin C (0.7 mg, 0.6 to 0.8), and folate (12.3 μ g, 9.7 to 20.4) in their total diet than children eating packed lunches. Implementation of school food policy standards was associated with significant improvements in the nutritional content of school lunches; this was reflected in children's total diet. School food- and nutrient-based standards can play an important role in promoting dietary health and may contribute to tackling childhood obesity. Similar policy measures should be considered for other environments influencing children's diet.

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Introduction

The causes, complexities and adverse health effects of obesity are well documented [1–5]. Diet has played a significant role in contributing to childhood obesity levels in the United Kingdom [4]. The National Child Measurement Programme identified 23% of reception (4–5 year olds) and 33% of year 6 (10–11 year olds) children in England as overweight or obese in 2011 [6]. National Diet and Nutrition Surveys report children's diets exceed recommended intakes of per cent energy from saturated fat and non-milk extrinsic sugars (NMES), and contain low levels of some micronutrients, such as iron [7,8]. Central to improving children's

diets is the need to reduce intakes of fat, saturated fat, and NMES, while increasing nutrient density.

Although the food children consume at home is of great importance, up to a third of children's daily energy and micronutrient intake is provided by school lunch [9]. Over the last four decades, policy changes have had a significant impact on the nutritional quality of school lunches in England. The 1980 Education Act removed nutritional standards, first introduced in 1941. Despite government introducing food-based standards for school lunches in 2001, [10] findings from a national survey of primary and secondary school lunches reported they contained too much fat and sugar, and lacked key micronutrients [9,11]. In February 2005, TV chef Jamie Oliver's media broadcast "Jamie's

School Dinners” attracted both public and Government attention and led to intensive lobbying by parents and pressure groups [12,13]. In March 2005, a national School Meal Review Panel was established to advise on school food, [14] and in April of the same year the School Food Trust was established to “transform school food” [15]. A major policy change ensued in England, which received legislative support in 2006 [16]. New food- and nutrient-based standards were introduced and primary schools were expected to comply by September 2008 [17]. Food-based standards specify which foods can and cannot be served, and how often. Nutrient-based standards apply to the average nutritional content of school lunches over three-weeks, and specify minimum and maximum levels [18]. Both food- and nutrient-based standards focus on planned provision, not consumption.

To date, research has focused on changes to school and packed lunch [19–22]. There is a lack of research in the UK examining the wider effects of this important policy change, i.e. on the impact of school food standards on children’s total dietary intake. In this paper, we report a natural experimental evaluation [23] to assess whether the introduction of food- and nutrient-based standards in primary schools had an impact on children’s lunchtime dietary intake and their total diet.

Methods

Ethics Statement

Ethical approval was granted by Newcastle University ethics committee (reference 000011/2007). Parents provided written informed consent prior to children’s participation.

Study Design, Setting and Participants

We undertook cross-sectional surveys during two academic years: 2003–4 (pre-) and 2008–9 (post-implementation) in 12 primary schools, North East England. The pre-implementation survey had been completed as part of a prior study [24]. The post-implementation survey used the same methods, which are described briefly here.

A letter with study details was posted to head teachers of the 16 primary schools that had participated in 2003–4. The results presented in this study are based on 12 schools for which comparable data were available from the two surveys. These schools had been identified to represent a comprehensive range of socio-economic circumstances, determined using the free school meal index at school level [25].

All children in Reception, Year 1 and Year 2 (aged 4–7 years) were eligible to participate. Each child received a letter with study details and a form requesting parental permission to participate in the study; consent forms were collected from schools by the study nutritionist.

Data Collection

We used a prospective, 24-hour food diary method (the *Food Assessment in Schools Tool (FAST)*), validated to record young children’s dietary intake [24]. FAST assesses foods within six defined daily time slots, along with age- and sex-specific portion sizes, derived from the National Diet and Nutrition Surveys (NDNS) [7].

Four consecutive days of dietary consumption were assessed: three week days and one weekend day. Full written instructions on how to complete the diary were provided to parents. At each school, a team of trained observers and the study nutritionist recorded dietary intake, including, breakfast and afterschool clubs. The diary design enabled categorisation of foods into ‘school lunch’, ‘packed lunch’, and ‘food eaten at home’. All dietary

coding for nutritional composition was based on McCance and Widdowson’s Integrated Composition of Food Dataset [26]. School recipes and menus were obtained to allow for coding of school food and assessing compliance with food- and nutrient-based standards.

All nutrients reported were checked for completeness in McCance and Widdowson’s Integrated Composition of Food Database [26]. To ensure consistency of dietary coding, all food codes, weights and food groups allocated were exported and interrogated, allowing identification and correction of inconsistencies.

Main Outcome Measures

Main outcome measures were changes in mean daily intakes of macro- and micro-nutrients in school lunch, packed lunch and total diet. The values for vitamins A and C had skewed distributions and were log-transformed before analysis.

Statistical Analysis

The sample size of the study was pragmatic and determined by the number of children studied in the earlier survey of the participating schools, and by the number of these schools prepared to participate in the more recent survey. Similar studies with smaller numbers of children aged 11–12 years have identified important and statistically significant changes in selected macro and micronutrients [27–29].

The first analysis assessed the direct effect of changes in school lunch standards, and considered only children who ate school lunches. The mean intake of macro- or micro-nutrients of each child from this source alone were compared between the 2003–4 and 2008–9 surveys. A more detailed analysis considered the intake of macro- and micro-nutrients from the total diet: this analysis explored the importance of year of the survey, whether the child ate a school or packed lunch, and the interaction between these factors. All analyses adjusted for the effect of gender and used a linear mixed effect model, with year (of survey), gender and packed/school lunch taken as fixed effects: potential correlation between responses within the same school and child were accommodated by fitting random effects for school and child. The models were fitted using *xtmixed* in Stata (version 10) and *lme* in R (version 2.14.0).

Results

Across all 12 schools, 586 (45% of those eligible) and 775 (55%) children consented in 2003–4, and 2008–9 respectively. Children eligible, consenting and completing, and reasons for exclusion are shown in Figure 1. The analyses included observed dietary intake from 407 children (boys $n = 198$; girls $n = 209$) in 2003–4, and 641 children (boys $n = 322$; girls $n = 319$) in 2008–9. In 2003–04, 233 children ate school lunch (boys $n = 106$; girls $n = 127$); in 2008–09, 323 children ate school lunch (boys $n = 164$; girls $n = 159$).

Lunchtime Intake: Change in Mean Daily Nutrients from School Lunches between 2003–4 and 2008–9

Table 1 shows the change in children’s mean daily macro- and micro-nutrient intake from school lunches. Between 2003–4 to 2008–9 there was a statistically significant fall in children’s mean daily per cent energy intake of fat (mean change -11.2% , 95% confidence interval -12.1 to -10.4), saturated fat (-5.3% , -5.8 to -4.7), and NMES (-1.3% , -1.9 to -0.7), despite a small increase in mean energy intake (44 kcal, 26.6 to 62.0). Post-implementation children’s mean daily intake of sodium fell; intakes of calcium, vitamin C, iron, zinc, vitamin A, and folate intake all

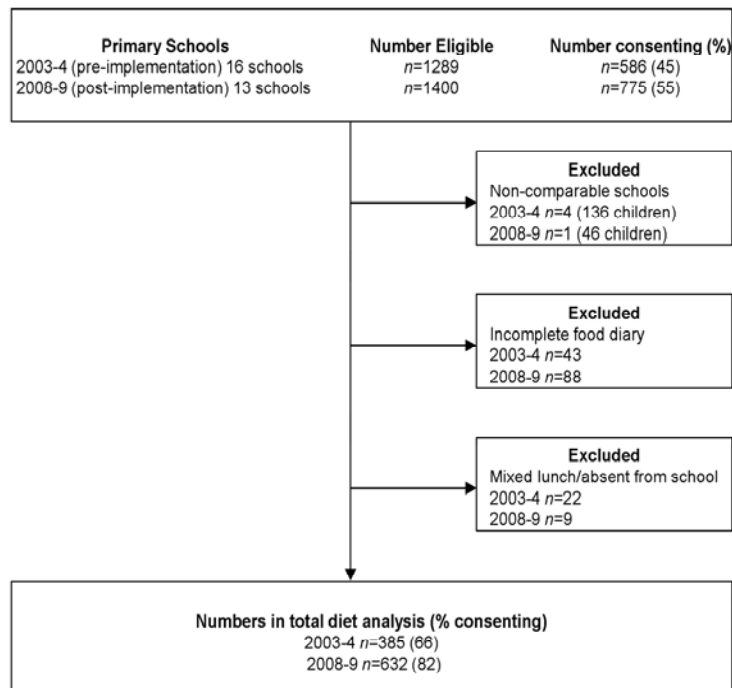


Figure 1. Flowchart detailing numbers (%) of children eligible, consenting, completing four-day food diaries and included in analysis.

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increased; these were also statistically significant (Table 1). In relation to the planned nutrient-based standards children's mean intake from calcium, iron, zinc and vitamin A remain below the minimum standard.

Total Dietary Intake: the Effect of Year and Lunch Type on Mean Daily Nutrient Intake

The results of the analysis of total diet are tabulated in Tables 2–4. Table 2 presents the results showing the effect of year, Table 3 the effect of lunch type, and Table 4 presents those variables for which there was a significant interaction between year and lunch type.

In children's total dietary intake between 2003–4 and 2008–9, there was a statistically significant reduction in mean daily intake of per cent energy from NMES (mean change -2.4% , 95% confidence interval -3.0 to -1.7), and in absolute intakes of fat (-9.5 g, -11.0 to -8.0), saturated fat (-4 g, -4.8 to -3.3), NMES (-16.9 g, -20.3 to -13.7), and sodium (-148 mg, -202 to -93). There was no evidence of a change in children's mean daily intake of vitamin A, calcium, iron, or zinc (Table 2). In 2008–9 children's mean daily intake of per cent energy from NMES and absolute amounts of sodium (mg) remain above the dietary reference value. Mean daily intakes of vitamin A (μg) and zinc (mg) remain below the dietary reference value.

Table 3 shows the effect of children's lunch type (school or home-packed lunch) on their mean total dietary intake adjusted for year (pre- and post-implementation). Children who ate school lunch consumed a lower mean per cent energy from NMES (mean change -2.6% , 95% confidence interval, -3.2 to -1.9) and lower absolute intakes of saturated fat (-1.5 g, -0.8 to -2.2), NMES (-10.3 g, -13.6 to -7.0), and sodium (-128 mg, -183 to -73)

than children eating a packed lunch. Mean daily intakes of vitamin A and zinc were higher in the total diets of children who ate a school lunch (Table 3). Although total fat intake was slightly lower and iron slightly higher in children who ate a school lunch, there was no statistically significant change. Children who ate a school lunch had a statistically significant lower intake of calcium (-29 mg, -54 to -4) in their mean total daily intake.

For a number of macro- and micro-nutrients examined, there was a significant interaction between year (pre- and post-implementation), and lunch type (school or home-packed lunch), and the consequent effect on total dietary intakes (Table 4). In 2003–4, children who ate a school lunch had a lower mean daily energy intake compared with children consuming a packed lunch (-57 kcal); by 2008–9, children who had a school lunch had a slightly higher mean daily energy intake, though this difference was very small (29 kcal). In 2003–4, children who ate a school lunch had a higher per cent energy from fat (0.6%); by 2008–9 children who ate a school lunch had a lower per cent energy from fat in their total diets than those who ate a packed lunch (-1.2%). Mean total daily per cent energy intake from saturated fat was lower in children who ate a school lunch in 2003–4 and remained lower in 2008–9 (Table 4). Carbohydrate and vitamin C intakes were lower in 2003–4 in those consuming school lunches; by 2008–9 children who ate a school lunch had a higher intake. In 2008–9 children who ate a school lunch had significantly higher mean daily total intakes of protein, NSP, and folate than children who ate packed lunches (Table 4). There was no statistically significant interaction between year and lunch type and children's mean daily total intake of per cent energy from NMES and absolute amounts of fat, saturated fat, NMES, sodium, vitamin A, calcium, iron, or zinc.

Table 1. School lunch: change in primary school children's mean daily intake of nutrients from 2003–4 to 2008–9 compared with planned nutrient-based standards.

Nutrient	Standard	Mean*		Mean difference [†]	95% CI	P-value [‡]
		2003–4	2008–9	2008–9–2003–4		
		n= 233	n= 323			
Energy (kcal)	target 530	450	494	44.0	26.6, 62.0	<0.001
% energy Fat	n/a	39.5	28.3	-11.2	-12.1, -10.4	<0.001
% energy Sat Fat	n/a	15.3	10.0	-5.3	-5.8, -4.7	<0.001
% energy NMES	n/a	9.4	8.1	-1.3	-1.9, -0.7	<0.001
Fat (g)	Max 20.6	19.9	15.6	-4.3	-5.1, -3.5	<0.001
Saturated Fat (g)	Max 6.5	7.7	5.5	-2.2	-2.5, -1.8	<0.001
Carbohydrate (g)	Min 70.6	57.1	71.4	14.3	11.6, 16.9	<0.001
Protein (g)	Min 7.5	14.3	19.2	4.9	4.2, 5.7	<0.001
NSP (g)	Min 4.2	2.9	4.7	1.8	1.6, 2.0	<0.001
NMES (g)	Max 15.5	11.4	10.6	-0.8	-1.6, 0.0	0.05
Sodium (mg)	Max 499	530	463	-67.0	-94.2, -39.8	<0.001
Calcium (mg)	Min 193	133	166	33.0	21.4, 43.6	<0.001
Vitamin C (mg) [§]	Min 10.5	11.8	46.0	3.9	3.5, 4.3	<0.001
Iron (mg)	Min 3	1.8	2.3	0.5	0.4, 0.6	<0.001
Zinc (mg)	Min 2.5	1.4	1.7	0.3	0.2, 0.4	<0.001
Vitamin A (µg) [†]	Min 175	69.2	84.5	1.2	1.0, 1.5	0.03
Folate (µg)	Min 53	45.7	59.1	13.4	10.2, 16.7	<0.001

*Mean adjusted for gender.

[†]Arithmetic means and differences are reported except for vitamins A and C (highly skewed) where geometric means and ratios are given.[‡]Confidence intervals and P-value derived from a linear mixed effects model with random term for schools.

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Discussion

Summary of Main Findings

This natural experimental evaluation of the nutrient standards for primary schools in England identified important reductions in both per cent energy and absolute intakes of fat, saturated fat, and

NMES in school and packed lunches post-implementation. While we observed a small increase in the energy content of a child's average school lunch post-implementation, the average energy content provided by either a school or packed lunch was similar post-implementation (494 and 504 kcal respectively) and remained below the target stated in the requirements of

Table 2. Total diet: effect of year on children's mean daily nutrient intake compared with Dietary Reference Values/Reference Nutrient Intakes*.

Nutrient	DRV/RNI	Mean [†]		Mean difference [‡]	95% CI	P-value
		2003–4	2008–9	2008–9–2003–4		
		n= 385	n= 632			
% energy NMES	11	18.0	15.6	-2.4	-3.0, -1.7	<0.001
Fat (g)	n/a	60.3	50.8	-9.5	-11.0, -8.0	0.001
Saturated Fat (g)	n/a	25.6	21.6	-4.0	-4.8, -3.3	<0.001
NMES (g)	60	77.5	60.6	-16.9	-20.3, -13.7	<0.001
Sodium (mg)	700	2000	1852	-148	-202, -93	<0.001
Vitamin A (µg) [‡]	400	210	224	1.08	1.00, 1.16	0.05
Calcium (mg)	450	677	669	-8.0	-33, 18	0.57
Iron (mg)	6.1	6.8	6.7	0.1	-0.2, 0.2	0.73
Zinc (mg)	6.5	4.9	4.9	0.0	-0.2, 0.1	0.77

*Dietary reference value/reference nutrient intake³⁵.[†]Mean adjusted for gender and lunch type.[‡]Geometric mean and ratio reported for vitamin A.

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Table 3. Total diet: effect of lunch type on children's mean daily nutrient intake compared with Dietary Reference Values/Reference Nutrient Intakes*.

Nutrient	DRV/RNI	Mean [†]		Mean difference [‡]	95% CI	P-value
		Packed Lunch	School Lunch	SL - PL [§]		
		n = 461	n = 556			
% energy NMES	11	17.9	15.3	-2.6	-3.2, -1.9	<0.001
Fat (g)	n/a	55.0	53.8	-1.2	-2.7, -0.4	0.13
Saturated Fat (g)	n/a	23.9	22.4	-1.5	-2.2, -0.8	<0.001
NMES (g)	60	72.6	62.3	-10.3	-13.6, -7.0	<0.001
Sodium (mg)	700	1978	1850	-128	-183, -73	<0.001
Vitamin A (µg) [‡]	400	206	230	1.12	1.04, 1.20	0.002
Calcium (mg)	450	688	659	-29	-54, -4	0.02
Iron (mg)	6.1	6.7	6.8	0.2	0.0, 0.4	0.12
Zinc (mg)	6.5	4.8	5.0	0.2	0.0, 0.3	0.02

*Dietary reference value/reference nutrient intake³⁵.[†]Mean adjusted for gender and year.[‡]Geometric mean and ratio reported for vitamin A.[§]SL (school lunch) PL (packed lunch).

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530 kcals/day. Post-implementation the average level of all micro-nutrients except calcium were higher in school lunches than packed lunches.

A number of these key changes in children's mean daily intake from school lunch were reflected in children's total diet. Post-implementation a child who ate a school lunch had a lower per cent energy derived from fat and saturated fat, but more carbohydrate, protein, NSP, vitamin C and folate in their total diet than children who ate a packed lunch. Findings show that children mean daily intake of % energy from saturated fat and NMES, and absolute amounts of sodium remain above Dietary Reference Values. Children's mean daily intake of Vitamin A and Zinc continue to remain below the Reference Nutrient Intake.

Strengths and Weaknesses of the Study

This natural experimental evaluation was dependent on repeated cross-sectional surveys, and as such, we were limited in the extent to which changes in nutrient intakes could be attributed to the implementation of the school food policy. Externally imposed time constraints for the implementation of the new standards precluded a stronger, prospective study design. Nevertheless, the study offers a unique evaluation of national policy, enabled by the availability of pre-implementation data, collected for an earlier study [24]. To avoid introducing measurement bias, the same methods were employed post-implementation. The study was restricted to a sample of primary schools in one city in North East England, which potentially limits generalisability.

Table 4. Total diet: effect of year and lunch type on children's mean daily nutrient intake compared with Dietary Reference Values/Reference Nutrient Intakes*.

Nutrient	DRV/RNI*	Mean [†]		Mean [‡]		Difference between differences	95% CI	P-value		
		2003-4		2008-9						
		SL	PL	SL	PL					
		n = 385	n = 632							
Energy (kcal)	§	1568.8	1625.3	1452.7	1423.6	-56.5	29.1	85.6	15.2, 156.1	0.02
% energy Fat	35	34.1	33.5	30.8	32.1	0.6	-1.2	-1.8	-2.8, -0.9	<0.001
% energy Sat Fat	11	14.3	14.5	12.8	14.0	-0.2	-1.2	-1.0	-1.6, -0.5	<0.001
Carbohydrate (g)	n/a	224.7	236.8	211.1	206.7	-12.1	4.3	16.4	5.3, 27.6	0.004
Protein (g)	19.7	47.2	47.1	50.3	46.6	0.1	3.7	3.6	1.1, 6.0	0.004
NSP (g)	n/a	8.7	8.5	10.5	8.8	0.2	1.7	1.5	0.5, 1.9	0.001
Vitamin C (mg) [‡]	30	58.1	67.8	89.0	72.6	1.2	0.8	0.70	0.60, 0.81	<0.001
Folate (µg)	100	163.3	160.0	171.7	155.9	3.5	15.8	12.3	9.7, 20.4	0.03

*Dietary reference value/reference nutrient intake³⁵.[†]Mean adjusted for gender.[‡]Geometric mean and ratio reported for vitamin C.[§]Boy (1715 kcals), Girl (1545 kcals).^{||}SL (Total intake of children having School Lunch), PL (Total intake of children having Packed Lunch).

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Food and nutrient-based standards for primary schools are based on the average school lunch over a three-week menu cycle. Some foods on which standards are based, such as oily fish, only have to be served once in this three week cycle. A potential limitation to assessing the impact of food and nutrient-based standards on children's total diet is that our data collection did not cover a full three week cycle in primary schools. However, there is a selection of food items available at school lunch each day. Children make choices both at the counter and, once seated, they may or may not choose to consume particular food items served. Our findings are based on children's actual food consumption.

Relationship to Previous Work

This study has shown changes in the nutrient content of both school and packed lunches, but also provides evidence of a widening gap between school and packed lunches. The finding that packed lunches contained more fat, saturated fat, sodium and NMES than school lunch confirms the findings of previous studies [20],[30–33]. This study, along with others, [19], [32,33] provides some evidence of the potential advantages of planned, nutrient-based lunch provision compared with home-prepared packed lunches. Our findings on total diet are similar to those of the NDNS [34] and show some improvements in children's nutrient intake over recent years. This study provides evidence that at least part of this improvement is associated with the change in school food policy. Although this study has not reported on children's weight gain following the implementation of the standards, a recent study in the US examined the impact of stricter nutritional standards and student weight gain [35]. Their findings show that, in states with stringent regulation of school food, children eating school lunches improved their weight status. This adds further support for regulation of foods offered at school lunch and the potential impact of such legislation on child health.

Future Research

Both the Healthy Lives, Healthy People (2010) [36] and Foresight [4] reports have highlighted the issue of social inequalities in children's diets. Schools offer a unique opportunity to influence the food choices of all children with the potential to reduce inequalities [37]. Further research is needed to assess whether the introduction of new school food- and nutrient-based standards has had a comparable effect on children's total diet across the socio-economic spectrum.

Conclusions and Implications

Although our findings show reductions in children's average daily intake of per cent energy from saturated fat and NMES, and

absolute intakes of NMES and sodium, intakes remain above the Dietary Reference Values [38]. These remain key areas for public health action, necessitating a focus on children's food choice at school and beyond. At school, more encouragement and supervision of children at lunchtime with selection of foods, more time to eat, and more child friendly dining environments have been advocated [39]. Following implementation of the nutritional standards, school lunches appeared to have a positive impact on children's total diet, but this can only be realised fully in children who eat school lunch. School lunch competes against packed lunch where children bring their choice of foods. Although it was observed some schools do impose rules (e.g. no sweets, chocolate, or crisps), there are more often no regulations as to what can and cannot be brought from home in a packed lunch.

It has been advocated that to address the complexity of obesity there is a need for political will [1,5], [40,41]. In 2011, Swinburn et al [39] commented that to enable 'healthy choices', policy interventions are required at the environment level. After a highly publicised campaign on the state of school lunches, government provided legislative and financial support for this change in policy, thereby creating an environment to enable healthier food choices in schools. Within the limitations of the natural experimental design, we found that children's total diet has improved since the reintroduction of food- and nutrient-based standards. Our findings of a positive effect on both lunchtime and total diet intake provide evidence to support this level of intervention in primary schools. Similar policy approaches should be considered for other schools and academies, and other environments influencing children's diet outside school. Prospective evaluation of public health policy interventions would add considerably to the evidence base.

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Author Contributions

Conceived and designed the experiments: AJA MW JM. Performed the experiments: SS JD. Analyzed the data: SS ES JM. Wrote the paper: SS JD ES JM MW AJA.

References

- Ebbeling C, Pawlak D, Ludwig D (2002) Childhood obesity: public health crisis, common sense cure. *Lancet* 360: 473–582.
- WHO (2003) Diet, Nutrition and the Prevention of Chronic Disease: Report of a Joint WHO/FAO Expert Consultation. Geneva: WHO.
- Lobstein T, Baur L, Uauy R (2004) Obesity in children and young people: a crisis in public health. *Obes Rev* 5 (Suppl.1): 4–85.
- Foresight (2007) Tackling obesity: Future Choices- Project Report.
- Han J, Lawlor D, Kimm S (2010) Childhood obesity. *Lancet* 375: 1737–1748.
- Department of Health (2011) National Child Measurement Programme: England, 2010/11 school year. London: Department of Health.
- Gregory J, Lowe S (2000) National Diet and Nutrition Survey: young people aged 4 to 18 years. London: HMSO.
- Bates B, Lennox A, Bates C, Swan G (2011) National Diet and Nutrition Survey: Headline results from years 1 and 2 (combined) of the Rolling Programme 2008/9–2009/10. London: Department of Health.
- Nelson M, Nicholas J, Sulciman S, Davies O, Prior G, et al. (2006) School meals in primary schools in England. London: Department for Education and Skills.
- The Education (Nutritional Standards for School Lunches) (England) Regulations 2000. Available: <http://www.legislation.gov.uk/ukxi/2000/1777/contents/made> Accessed 2012 Sep 20.
- Nelson M, Bradbury J, Poulter J, McGee A, Msebele S, et al. (2004) School Meals in Secondary Schools in England. London: Department for Education and Skills.
- Spence D (2005) Jamie's School Dinners. *British Medical Journal* 330. doi: <http://dx.doi.org/10.1136/bmj.330.7492.678> Accessed 2013 Apr 17.
- BBC NEWS Oliver's school meal crusade goes on. Available: <http://news.bbc.co.uk/go/pr/fr/-/1/hi/uk/5313882.stm> Accessed 2013 Apr 17.
- School Meals Review Panel (2005) Turning the Tables. Transforming School Food: A report on the development and implementation of nutritional standards for school lunches.
- School Food Trust Food-based and nutrient-based standards for school lunches and food other than lunches. Available: www.schoolfoodtrust.org.uk/the-standards Accessed 2012 Mar 28.

16. The Education (Nutritional Standards and Requirements for School Food) (England) (Amendment) Regulations 2008. Available: http://www.opsi.gov.uk/si/si2008/pdf/uksi_20081800_en.pdf. Accessed 2012 Mar 28.
17. Department for Education and Skills (2006) Nutritional Standards for school lunches and other school food. London: Department for Education and Skills.
18. School Food Trust A Guide to introducing the Government's food-based and nutrient-based standards for school lunches Available: www.childrensfoodtrust.org.uk/resources/guide-to-the-nutrient-based-standards Accessed 2013 Jun 13.
19. Rogers IS, Ness AR, Hebditch K, Jones LR, Emmett PM (2007) Quality of food eaten in English primary schools: school dinners vs packed lunches. *Eur J Clin Nutr* 61: 856–864.
20. Rees GA, Richards CJ, Gregory J (2008) Food and nutrient intakes of primary school children: a comparison of school meals and packed lunches. *J Hum Nutr Diet* 21: 420–427.
21. Haroun D, Harper C, Wood L, Nelson M (2010) The impact of the food-based and nutrient-based standards on lunchtime food and drink provision and consumption in primary schools in England. *Public Health Nutr* 14: 209–218.
22. Golley R, Pearce J, Nelson M (2010) Children's lunchtime food choices following the introduction of food-based standards for school meals: observations from six primary schools in Sheffield. *Public Health Nutr* 14: 271–278.
23. Craig P, Cooper C, Gunnell D, Haw S, Lawson K, et al. (2012) Using natural experiments to evaluate population health interventions: new Medical Research Council guidance. *J Epidemiol Community Health*.doi:10.1136/jech-2011-200375.
24. Adamson AJ, Griffiths JM, Carlin LE, Barton KL, Wrieden WL, et al. (2003) FAST: Food Assessment in Schools Tool. *Proc Nutr Soc* 62: 84A.
25. Directgov.co.uk. Available: www.direct.gov.uk/en/Parents/Schoolslearninganddevelopment/SchoolLife/DG_4016089. Accessed 2012 Aug 29.
26. Food Standards Agency (2002) McCance and Widdowson's the Composition of Foods, Sixth Summary Edition. Cambridge: The Royal Society of Chemistry.
27. Adamson AJ, Rugg-Gunn AJ, Butler TJ, Appleton DR, Hackett AF (1992) Nutritional intake, height and weight of 11–12-year-old Northumbrian children in 1990 compared with information obtained in 1980. *Br J Nutr* 68: 543–563.
28. Rugg-Gunn AJ, Fletcher ES, Matthews JNS, Hackett AF, Moynihan PJ, et al. (2007) Changes in consumption of sugars by English adolescents over 20 years. *Public Health Nutr* 10: 354–363.
29. Fletcher ES, Rugg-Gunn AJ, Matthews JNS, Hackett A, Moynihan PJ, et al. (2004) Changes over 20 years in macronutrient intake and body mass index in 11- to 12-year old adolescents living in Northumberland. *Br J Nutr* 92: 321–333.
30. Evans CEL, Greenwood DC, Thomas JD, Cade JE (2010) A cross-sectional survey of children's packed lunches in the UK: food-and nutrient-based results. *J Epidemiol Community Health* 64: 977–983.
31. Evans CEL, Greenwood DC, Thomas JD, Cleghorn CL, Kitchen MS, et al. (2010) SMART lunch box intervention to improve the food and nutrient content of children's packed lunches: UK wide cluster randomised controlled trial. *J Epidemiol Community Health* 64: 970–976.
32. Gatenby L (2011) Children's nutritional intake as part of the Eat Well Do Well scheme in Kingston-upon-Hull—a pilot study. *Nutr Bull* 36: 87–94.
33. Pearce J, Harper C, Haroun D, Wood L, Nelson M (2011) Key differences between school lunches and packed lunches in primary schools in England in 2009. *Public Health Nutr* 14: 1507–1510.
34. Bates B, Lennox A, Swan G (2010) National Diet and Nutrition Survey—headline results from year 1 (2008–2009). London: Department of Health.
35. Taber D, Chriqui J, Powell L, Chaloupka F (2013) Association between state laws governing school meal nutrition content and student weight status. *JAMA Pediatr*.doi:10.1001/jamapediatrics.2013.399.
36. HM Government (2010) Healthy Lives, Healthy People: Our strategy for public health in England. London: HMSO.
37. The Marmot Review (2010) Fair Society, Healthy Lives. London: The Marmot Review.
38. Department of Health (1991) Dietary Reference Values for Food Energy and Nutrients for the United Kingdom. London: HMSO.
39. Adamson A, White M, Stead M, Delves J, Stamp E, et al. (2011) The process and impact of change in the school food policy on food and nutrient intake of children aged 4–7 and 11–12 years both in and out of school; a mixed methods approach. Available: http://phrc.lsh.um.ac.uk/papers/PHRC_B5-07_Final_Report.pdf.
40. Gortmaker SL, Swinburn BA, Levy D, Carter R, Mabry PL, et al. (2011) Changing the future of obesity: science, policy and action. *Lancet* 378: 838–846.
41. Swinburn BA, Sacks G, Hall KD, McPherson K, Finegood DT, et al. (2011) The global obesity epidemic: shaped by drivers and local environments. *Lancet* 378: 804–814.

**5.3 Paper III Did school food and nutrient-based standards in England impact on 11-12y olds nutrient intake at lunchtime and in total diet?
Repeat cross-sectional study**



Did School Food and Nutrient-Based Standards in England Impact on 11–12Y Olds Nutrient Intake at Lunchtime and in Total Diet? Repeat Cross-Sectional Study

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Abstract

Introduction: In September 2009, middle and secondary schools in England were required to comply with food and nutrient-based standards for school food. We examined the impact of this policy change on children's lunchtime and total dietary intake.

Methods: We undertook repeat cross-sectional surveys in six Northumberland middle schools in 1999–2000 and 2009–10. Dietary data were collected from 11–12 y olds ($n=298$ in 1999–2000; $n=215$ in 2009–10). Children completed two consecutive 3-day food diaries, each followed by an interview. Linear mixed effect models examined the effect of year, lunch type and level of socio-economic deprivation on children's mean total dietary intake.

Results: We found both before and after the introduction of the food and nutrient-based standards children consuming a school lunch, had a lower per cent energy from saturated fat (-0.5% ; $p=0.02$), and a lower intake of sodium (-143 mg; $p=0.02$), and calcium (-81 mg; $p=0.001$) in their total diet, compared with children consuming a home-packed lunch. We found no evidence that lunch type was associated with mean energy, or absolute amounts of NSP, vitamin C and iron intake. There was marginal evidence of an association between lunch type and per cent energy NME ($p=0.06$). In 1999–2000, children consuming a school lunch had a higher per cent energy from fat in their total diet compared with children consuming a home-packed lunch (2.8%), whereas by 2009–10, they had slightly less (-0.2%) (year by lunch type interaction $p<0.001$; change in mean differences -3%).

Conclusions: We found limited evidence of an impact of the school food and nutrient-based standards on total diet among 11–12 year olds. Such policies may need to be supported by additional measures, including guidance on individual food choice, and the development of wider supportive environments in school and beyond the school gates.

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Introduction

Reducing childhood overweight and obesity are public health priorities [1]; improving diet is central to achieving a healthier lifestyle and losing weight [2,3]. Although there is some evidence

of a levelling off in childhood obesity [4,5], in 2011–12, the National Child Measurement Programme in England identified a third of 10–11 y olds as overweight or obese [6], and socio-economic disparities persist [4,7].

Obesity has been found to track from adolescence to adulthood [8,9]; one potentially contributing factor is poor dietary patterns [9]. The English National Diet and Nutrition Survey found per cent energy from saturated fat and non-milk extrinsic sugar (NMES) exceeded the Dietary Reference Value of 11%; per cent energy from NMES was highest in 11–18 y olds (15.3%) [10]. Only 11% of boys and 8% of girls met the recommended '5-a-day' for fruit and vegetables [10]. Certain micronutrients, for example iron, were below the Reference Nutrient Intake.

Improving dietary intake in this age group is complex. During adolescence there is increasing independence in food choice [11] with social factors playing a crucial role [12–14]. For adolescents, food and drink consumption is related to 'identity' and 'status' [12,13]. One effort to tackle adolescent's diets has been a change in government policy requiring middle and secondary schools in England to comply with food and nutrient-based standards for school food from September 2009 [15]. These specify the provision of certain foods and the average nutrient content school lunches must provide over a three week menu cycle [16]. The majority of studies exploring the impact of the food and nutrient-based standards have focused on change in lunchtime intake in primary schools [17–24]; few have reported on middle and secondary schools [25,26]. Following the implementation of nutritional standards, Fletcher et al. reported the increased selling of junk food by students and suggested these standards ignore the wider contextual issues associated with food choice [14]. Studies have also highlighted negative aspects of school lunches, for example pricing [14] and a preference to socialise with friends at lunchtime [12]. Findings also reveal negative aspects of the dining environment, for example overcrowding, queuing [12,14,27] and noise [14].

With limited findings from quantitative studies, it is important to examine whether the food and nutrient-based standards could potentially affect nutrient intake among adolescents. In this paper we report research which examined the impact of the introduction of food and nutrient-based standards for school lunch on the lunchtime and total diet of a representative sample of children aged 11–12 years, between 1999–2000 (before) and 2009–10 (after) introduction of the policy in England.

Methods

Ethics statement

Ethical approval was granted by Newcastle University ethics committee (reference 000011/2007). In 2009–10, Newcastle University ethics committee granted approval for opt-out to be used as the method of consent (reference 00011/2009). Parents

were provided with a written information letter about the study and a consent form, however, they were only required to return the consent form if they did not wish their child to participate. Newcastle University ethics committee approved our study design, methods and the consent procedure used for this study. All the data in this study were anonymised.

Study design, setting and participants

Cross-sectional studies were undertaken in middle schools in Morpeth, Ashington and Newbiggin-by-the-Sea in Northumberland, North East England over two academic years: 1999–2000 (before) and 2009–10 (after implementation of the standards). These areas were previously selected to be representative of schools with catchment populations across the socio-economic spectrum [28,29]. The 1999–2000 data were collected as part of a series of studies conducted in Northumberland [11,30–32] to track changes in dietary patterns and used as the baseline in this study. The same schools were invited by letter in 2009 to participate in this study. This was followed up with a school visit to answer questions and ascertain interest. During discussions with heads of schools they suggested consent should be changed from 'opt-in' (as used in the previous studies in these schools) to 'opt-out'. The rationale was that by using opt-in we excluded children whose parents failed to return forms sent by schools, rather than just those children whose parents actively did not want their child to participate. After obtaining documented support from heads and school governors, an amendment to the Newcastle University Ethics approval was granted for the use of opt-out in 2009–10 (reference 00011/2009). One head preferred that his school continued to use opt-in (this was the smallest school) and the decision was taken to retain this school despite a different method used in the consent process. Children could still exclude themselves by not completing food diaries and were free to leave the study at any time.

All children in year 7 were eligible to participate. A presentation was given at individual schools and each child received a parental information letter and a consent form to return if they did not wish to participate. Participating children received a unique identification number to anonymise data. All data were stored securely according to Newcastle University policies and regulations.

Data

Dietary consumption. We used dietary assessment methods identical to those used in the previous Northumberland studies [11,30]. This method has been described in detail [11,27,30,33] and validated [29,34]; a brief overview is provided here. Verbal

Table 1. Number of children consenting and reasons for exclusion in 1999–2000 and 2009–10.

	1999–2000	2009–10
Number consenting	n = 424	n = 295
Reasons for exclusion:		
From non-comparable school*	19	–
Mixed lunch [†]	96	73
No postcode	6	7
Completed less than 6 food diary days	5	0
Number included in analysis	298	215

*Non-comparable school: one school had closed from 1999–2000 to 2009–10.

[†]Mixed lunch means a child having both a school and home-packed lunch.

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Table 2. Number (percentage) of children consuming a school lunch by year and level of deprivation.

Level of deprivation	1999–2000		2009–10		[1999–00]–[2009–10]	
	No. having school lunch	Total *	No. having school lunch	Total *	Total (%)	Decrease in %
Quintile 1 (least)	44	54	12	81	55	20
Quintile 2	43	55	11	78	41	27
Quintile 3	40	50	15	80	34	44
Quintile 4	38	49	10	78	26	38
Quintile 5 (most)	75	90	30	83	59	51
All children	240	298	78	81	215	36

*Total = no. having school and home-packed lunch.
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instructions on how to complete the diary were given to each participating child; the diary also included an example page with instructions. Children recorded the day, date and time when food or drink was consumed, descriptions of items and amounts of foods/drinks for two consecutive three-day periods (for example Thursday, Friday, Saturday and Sunday, Monday, Tuesday). On the fourth day the child was interviewed by a trained researcher to clarify information recorded and estimate portion size using food models and a photographic food atlas for 11–14 y olds [35]. Foods were coded using McCance and Widdowson's Integrated Composition of Food dataset [36]. If available, school recipes were used to code school lunch, and if not, foods were coded as above. Foods were categorised into 'school lunch', 'home-packed lunch' and 'food consumed outside of school hours'. In common with the large majority of secondary schools in England [37] none of the schools permitted pupils to leave school premises at lunchtime. The macro- and micronutrients examined in this paper relevant to the nutrient-based standards are: energy (kcal), per cent energy from fat, saturated fat, and non-milk-extrinsic sugars (NMES); and absolute amounts of non-starch polysaccharides (NSP) (g), sodium (mg), vitamin C (mg), calcium (mg) and iron (mg).

Socio-economic status. Socio-economic status was estimated using the English Index of Multiple Deprivation (IMD) 2007 [38], allocated using individual children's postcodes. IMD is calculated at lower layer super output areas in England and provides a single deprivation score based on seven domains: income, employment, health and disability, education, skills and training, barriers to housing and services, crime and living environment [38]. The IMD scores were categorised into quintiles for the analyses: quintile 1 included children living in the 20% least deprived areas, quintile 5 included children living in the 20% most deprived areas.

Main outcome measures

Main outcome measures were mean daily intakes of macro- and micronutrients in 'school lunch', 'home-packed lunch' and total diet, measured as indicated below.

Statistical analysis

We undertook three sets of analyses. The first considered the change in school lunch take-up. A linear model was fitted directly to the proportions taking school lunch using maximum likelihood (fitted in R using *optim*), which allowed for differences between IMD quintiles, between years and their interaction. The second examined the change at lunchtime in children's mean macro- and micronutrient intake from a school or home-packed lunch on school days only between 1999–2000 and 2009–10. The third analysis considered the intake of macro- and micronutrients in children's total diet: this explored the effect of year (before and after the food and nutrient-based standards), lunch type (school or home-packed lunch) and level of deprivation. We used linear mixed effect models to examine the effect of these variables; interactions between variables were considered (year by lunch type, year by level of deprivation and lunch type by level of deprivation). Where there was no evidence for a particular interaction for a given nutrient, the interaction was excluded from the final model. All analyses adjusted for the effect of gender and day type (week or weekend day). Within each model random effects were included for school and child. Data were analysed using Stata version 11 and models were fitted using *xtmixed*. Vitamin C was log transformed for analysis, and for this variable geometric means and ratios are reported in tables.

Table 3. Lunchtime: Change in children's mean daily nutrient intake from school lunch between 1999–2000 and 2009–10, and nutrient-based standards [16].

Nutrient	Standard	Consumption from school lunch				
		1999–2000	2009–10	[2009–10]–[1999–2000]		
		n = 240	n = 78	mean*	mean difference	95% CI for difference
Energy (kcal)	610	729	497	–232	–276; –189	<0.001
% energy fat	–	40.6	30.7	–9.9	–11.4; –8.6	<0.001
% energy saturated fat	–	12.5	10.6	–1.9	–2.7; –1.3	<0.001
% energy NMES	–	11.9	13.0	1.1	–0.4; 2.7	0.2
NSP (g)	min 4.9	3.9	3.2	–0.7	–1.0; –0.4	<0.001
Sodium (mg)	max 714	908	518	–390	–453; –328	<0.001
Vitamin C (mg) ‡	min 12.3	28.8	28.2	1.0	0.9; 1.1	0.7
Calcium (mg)	min 350	206.5	184.2	–22.3	–44.4; –0.3	0.05
Iron (mg)	min 5.2	2.8	2.1	–0.7	–0.9; –0.5	<0.001

*Mean adjusted for gender.

†P-value derived from a linear mixed effects model.

‡Vitamin C log transformed; geometric means and ratios reported.

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Results

Study sample characteristics

Table 1 shows the number of children who consented to take part by year and reasons for exclusion. There was a similar percentage of males and females participating in 1999–2000 (m = 47%; f = 53%) and 2009–10 (m = 50%; f = 50%), and there was no evidence of a statistically significant difference in children's mean IMD score ($p = 0.3$).

From Table 2 it can be seen that school lunch take-up was similar across all IMD quintiles in 1999–2000: between 1999–2000 and 2009–10 there was a decrease in the percentage of children consuming a school lunch, with evidence that the

decrease differed across the IMD quintiles. The fall in school lunch take-up decreased linearly across the IMD quintiles (linear by year interaction $p = 0.01$, likelihood ratio test), with a fall of 61 percentage points in the least deprived group compared with a mean reduction of 32 percentage points in the most deprived group.

Lunchtime diet

Tables 3 and 4 show the change in children's mean daily nutrient intake in school and home-packed lunches respectively between 1999–2000 and 2009–10, compared with the nutrient-based standards [16]. In school lunches, between 1999–2000 and

Table 4. Lunchtime: Change in children's mean daily nutrient intake in home-packed lunch between 1999–2000 and 2009–10, and nutrient-based standards [16].

Nutrient	Standard	Consumption from home-packed lunch				
		1999–2000	2009–10	[2009–10]–[1999–2000]		
		n = 58	n = 137	mean*	mean difference	95% CI for difference
Energy (kcal)	610	605	578	–27	–77; 23	0.3
% energy fat	–	34.0	32.3	–1.7	–4.0; 0.7	0.2
% energy saturated fat	–	14.1	14.2	0.1	–1.3; 1.5	0.8
% energy NMES	–	17.8	17.1	–0.7	–3.0; 1.7	0.6
NSP (g)	min 4.9	2.9	3.4	0.5	0.04; 1.0	0.03
Sodium (mg)	max 714	954	889	–65	–165; 34	0.2
Vitamin C (mg) ‡	min 12.3	26.9	34.7	1.3	1.1; 1.6	0.006
Calcium (mg)	min 350	223.2	292.1	68.9	21.1; 116.7	0.005
Iron (mg)	min 5.2	2.6	2.4	–0.2	–0.5; 0.1	0.3

*Mean adjusted for gender.

†P-value derived from a linear mixed effects model.

‡Vitamin C log transformed; geometric means and ratios reported.

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2009–10, there was strong evidence of a decrease in mean energy intake (mean difference -232 kcal; $p < 0.001$), per cent energy from fat (-9.9% ; $p < 0.001$) and saturated fat (-1.9% ; $p < 0.001$), and in absolute amounts of sodium (-390 mg; $p < 0.001$), but also a decrease in mean NSP (-0.7 g; $p < 0.001$) and iron intake (-0.7 mg; $p < 0.001$). We found no evidence of a change in per cent energy from NMES (1.1% ; $p = 0.2$), mean vitamin C (ratio 1.0; $p = 0.7$) and marginal evidence of a change in calcium intake (-22.3 mg; $p = 0.05$) (Table 3). In 1999–2000, children's mean energy and sodium intake from school lunch were above the target for the current school nutrient-based standards. By 2009–10, mean intakes were below these targets [16]. In 1999–2000, mean intakes of NSP, calcium, iron and vitamin C intake were below the nutrient-based standards [16]; these deficits persisted in 2009–10 (Table 3).

In packed lunches, between 1999–2000 and 2009–10, there was a statistically significant increase in absolute amounts of mean NSP (mean difference 0.5 g; $p = 0.03$), calcium (68.9 mg; $p = 0.005$) and vitamin C intake (1.3 ; $p = 0.006$) (Table 4). We found no evidence of a change in mean energy (-27 kcal; $p = 0.3$), per cent energy from fat (-1.7% ; $p = 0.2$), saturated fat (0.1% ; $p = 0.8$), NMES (-0.7% ; $p = 0.6$), or absolute amounts of sodium (-65 mg; $p = 0.2$) or iron intake (-0.2 mg; $p = 0.3$) (Table 4).

Total diet

The results from the total diet analysis are shown in Tables 5, 6, 7 and Figure 1. Table 5 shows the effect of year (before and after the food and nutrient-based standards), Table 6 the effect of lunch type (school or home-packed lunch) and Table 7 the effect of level of deprivation. There was evidence of a year by lunch type interaction only for per cent energy from fat (Figure 1).

In total diet, between 1999–2000 and 2009–10, there was strong evidence of a decrease in mean energy intake (mean difference -259 kcal; $p < 0.001$), and absolute amounts of sodium (-475 mg; $p < 0.001$), but also a decrease in NSP (-0.9 g; $p = 0.002$), and iron intake (-1.0 mg; $p < 0.0001$). Mean calcium and vitamin C intake increased (104 mg; $p < 0.001$ and ratio 1.2; $p < 0.001$ respectively) (Table 5). We found no evidence of a change in per cent energy from saturated fat (-0.2% ; $p = 0.4$) or NMES (-0.5% ; $p = 0.3$) (Table 5). In 2009–10, children's per cent energy from saturated

fat and NMES remained above the recommendation of $\leq 11\%$ [39]. Mean vitamin C intake was the only micronutrient to meet the Reference Nutrient Intake [39].

Table 6 shows the effect of lunch type (school or home-packed lunch) on children's mean total dietary intake, with data from before and after the introduction of the legislation combined. There was clear evidence that children who consumed a school lunch both before and after the implementation of the food and nutrient-based standards had a lower per cent energy from saturated fat (mean difference -0.5% ; $p = 0.02$), and absolute amounts of sodium (-143 mg; $p = 0.02$), and calcium intake (-81 mg; $p = 0.001$) compared with children who consumed a packed lunch (Table 6). We found no evidence of a statistically significant effect of lunch type on mean energy, or absolute amounts of NSP, vitamin C and iron intake in total diet. We found marginal evidence of an effect on per cent energy from NMES (-0.9% ; $p = 0.06$) (Table 6).

In both 1999–2000 and 2009–10, we found strong evidence of a level of deprivation effect on mean vitamin C intake. Mean intakes were lowest for children in the most deprived quintile (test for the effect of level of deprivation: $p < 0.001$, Table 7). We found no evidence of an effect on mean energy, per cent energy from fat, saturated fat, NMES, or absolute amounts of NSP and sodium intake. We found marginal evidence of an effect on mean calcium and iron intake. Mean intakes were lowest for those in the most deprived quintile (test for the effect of level of deprivation: $p = 0.04$ and $p = 0.08$ respectively) (Table 7).

For one nutrient, per cent energy from fat, we found a statistically significant year by lunch type interaction on children's total dietary intake ($p < 0.001$; Figure 1). This was because there was a markedly higher per cent energy from fat in school lunches compared with packed lunches in 1999–2000 (35.9% and 33.1% respectively; mean difference 2.8%), whereas the corresponding difference in 2009–2010 was very small (31.9% and 32.1% respectively; -0.2%). The change in these differences: (2009/10–1999/00) is $(-0.2) - 2.8 = -3\%$ (95% CI -4.4 to -1.4 ; see Figure 1). We found no evidence of any statistically significant year by level of deprivation or lunch type by level of deprivation interactions.

Table 5. Total diet: The effect of year on children's mean daily nutrient intake and Dietary Reference Values/Reference Nutrient Intakes (DRV/RNI) [39].

Nutrient	DRV/RNI	1999–2000*	2009–10	[2009–10]–[1999–2000]		
		Mean [†]		Mean difference	95% CI for difference	p-value [‡]
Energy (kcal)	M [§] = 2220; F [§] = 1845	1924	1665	-259	$-332; -185$	<0.001
% energy saturated fat	≤ 11	12.9	12.7	-0.2	$-0.6; 0.2$	0.4
% energy NMES	≤ 11	16.5	16.0	-0.5	$-1.3; 0.4$	0.3
NSP (g)	–	10.8	9.9	-0.9	$-1.5; -0.3$	0.002
Sodium (mg)	1600	2593	2118	-475	$-590; -361$	<0.001
Vitamin C (mg)	35	67.6	79.4	1.2	1.1; 1.3	<0.001
Calcium (mg)	M = 1000; F = 800	698	802	104	60; 149	<0.001
Iron (mg)	M = 11.3; F = 14.8	9.6	8.6	-1.0	$-1.6; -0.5$	<0.001

*Number of children participating in 1999–2000 ($n = 298$) and 2009–10 ($n = 215$).

[†]Mean adjusted for gender, day-type, lunch type and level of deprivation.

[‡]95% CI and p-value derived from a linear mixed effects model.

[§]M (male) F (female).

^{||}Vitamin C log transformed; geometric means and ratios reported.

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Table 6. Total diet: The effect of lunch type (school or home-packed lunch) on children's mean daily nutrient intake and Dietary Reference Values/Reference Nutrient Intakes (DRV/RNI) [39].

Nutrient	DRV/RNI	Packed (PL)*	School (SL)	[SL-PL]	95% CI for difference	p-value [‡]
		Mean [†]		Mean difference		
Energy (kcal)	M [§] = 2220; F [§] = 1845	1792	1788	-4	-78; 71	0.9
% energy saturated fat	≤11	13.2	12.7	-0.5	-0.9; -0.1	0.02
% energy NMES	≤11	16.9	16.0	-0.9	-1.8; 0.0	0.06
NSP (g)	-	10.1	10.2	0.1	-0.5; 0.7	0.8
Sodium (mg)	1600	2490	2347	-143	-261; -26	0.02
Vitamin C (mg)	35	70.8	72.4	1.0	0.9; 1.1	0.5
Calcium (mg)	M = 1000; F = 800	778	697	-81	-127; -35	0.001
Iron (mg)	M = 11.3; F = 14.8	9.2	8.8	-0.4	-0.9; 0.2	0.2

*Number of children participating in 1999–2000 (n = 298) and 2009–10 (n = 215).

[†]Mean adjusted for year, gender, day-type and level of deprivation.

[‡]95% CI and p-value derived from a linear mixed effects model.

[§]M (male) F (female).

^{||}Vitamin C log transformed; geometric means and ratios reported.

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Discussion

Summary of key findings

Between 1999–2000 and 2009–10, the number of children consuming a school lunch decreased with the greatest decline in children from more affluent families. At lunchtime, in 2009–10, we found that children eating school lunches consumed a healthier diet with regard to per cent energy from fat, saturated fat, NMES and sodium, but had a lower mean micronutrient intake than children consuming packed lunches. In total diet, between 1999–2000 and 2009–10, there was a statistically significant decrease in mean intakes of energy and sodium, but also a decrease in NSP and iron, while vitamin C and calcium intake increased. We found no evidence of a change in per cent energy from NMES or saturated fat. There was limited evidence that a child's lunch type was associated with a change in children's mean total dietary intake. The only association found between year (before and after the introduction of the food and nutrient-based standards) and a child's lunch type (school or home-packed lunch) was in relation to per cent energy from fat consumed. By 2009–10, children who consumed a school lunch had a slightly lower intake of per cent energy from fat in their total diet compared with those who consumed a home-packed lunch. We found little evidence that mean nutrient intakes were associated with level of deprivation.

Relationship to other studies

In 2009–10, school lunch take-up in the six Northumberland middle schools participating in this study was 36%. A study in English academies and city technology colleges found school lunch take-up was 37.6% in 2010–11 [40].

There is limited research examining the impact (before and after implementation) of the food and nutrient-based standards in England on dietary intake at lunchtime and the impact of this policy change on total diet in 11–12 y olds. A number of studies have examined nutritional intake in this age group at school or in their total diet. What this study adds is a consideration of school and home-packed lunch both separately and in the context of total diet, prior to and following a major change in school food policy.

At lunchtime, we found mean energy, NSP, calcium and iron intakes were below the nutrient-based standards in both school and home-packed lunches; however, vitamin C was above. These

findings are similar to those from a national survey of 80 secondary schools in England [26]. In school lunch, per cent energy from fat, saturated fat and NMES were comparable with the national survey. In home-packed lunch, we found a lower per cent energy from fat, but a higher per cent energy from saturated fat and NMES compared with the national survey. In contrast to other studies, [26,41,42] we found that a school lunch provided a lower mean energy, NSP, and micronutrient intake than a home-packed lunch. Our findings concur with those by Hur et al [43] and Taylor et al [44] who found children who consumed a school lunch had a lower mean energy intake than children consuming a home-packed lunch. Similarly Taylor et al [44] also found lower intakes of some micronutrients, such as iron and vitamin C. The lower mean intakes of micronutrients for children consuming a school lunch in our study may be due to the lower mean energy intake which highlights the need for increased nutrient quality with lower energy intakes. These findings show some inconsistencies in energy and some micronutrient intakes in studies that have investigated what children eat in a school or home-packed lunch. These differences may be due to a number of factors, for example: age of children studied and variation in food provision and wider support to which children are exposed, however, differences due to dietary data collection methods cannot be excluded. A study by Pearce et al [45] showed that some portion sizes of foods on offer had decreased since the implementation of the policy; variation in portion sizes served across schools may also explain inconsistencies in findings.

A study by Fung et al [46] that examined change in children's total diet pre to post-school lunch policy in Canada (Grade 5 children) reported similar findings to our study. For example, they found a decrease in per cent energy from fat and absolute amounts of sodium; and also a decrease in mean fibre intake. In contrast to our study they found mean iron intake increased. [46] In total diet, we found children's mean energy, calcium and iron intake were below recommended intakes [39]; per cent energy from saturated fat and NMES, and absolute amounts of sodium were above. This is similar to findings from 11–18 y olds in the National Dietary and Nutrition Survey (NDNS) [47]. Between 1999–2000 and 2009–10, we found a decrease in energy, per cent energy from fat and saturated fat, and little change in per cent energy from NMES. Mean vitamin C and calcium intake increased, but iron

Table 7. Total diet: The effect of level of deprivation on children's mean daily nutrient intake and Dietary Reference Values/Reference Nutrient Intakes (DRV/RNI) [39].

Nutrient	DRV/RNI	Level of deprivation					p-value [†]
		1 (least deprived) [*] Mean [‡]	2	3	4	5 (most deprived)	
Energy (kcal)	M [§] = 2220; F = 1845	1773	1830	1813	1821	1747	0.4
% energy fat	≤ 35	33.5	33.6	33.9	34.1	34.4	0.2
% energy saturated fat	≤ 11	12.6	12.9	12.9	13.1	12.8	0.7
% energy NMEs	≤ 11	16.3	16.7	16.2	15.8	16.4	0.8
NSP (g)	–	10.1	10.4	10.4	10.5	9.8	0.5
Sodium (mg)	1600	2421	2452	2407	2484	2310	0.2
Vitamin C (mg)	35	81.3	79.4	77.6	67.6	61.7	<0.001
Calcium (mg)	M = 1000; F = 800	744	763	753	723	680	0.04
Iron (mg)	M = 11.3; F = 14.8	8.9	9.4	9.4	8.8	8.5	0.08

^{*}Number of children participating in 1999–2000 (n = 298) and 2009–10 (n = 215).

[†]Mean adjusted for year, lunch type, gender and day-type.

[‡]p-value derived from a linear mixed effects model.

[§]M (male) F (female).

^{||}Vitamin C log transformed; geometric means and ratios reported.

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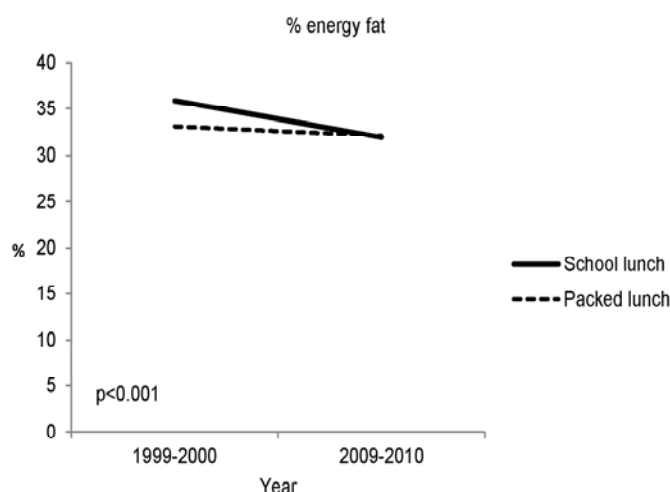


Figure 1. Total diet: The effect of year and lunch type interaction on children's per cent energy from fat (adjusted for gender, level of deprivation and day type).

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decreased; these findings are also similar to the trends observed in the NDNS [47,48]. This decrease in mean energy and per cent energy from fat was also observed in a previous study in Northumberland examining the macronutrient intake in 11–12 y olds between 1980 and 2000 [11]. In contrast, in this later study we found no evidence of a change in per cent energy from NMES which remained above recommended intakes [38] (16% compared with 11%). This suggests products with a high sugar content, such as breakfast cereals, confectionery and fruit juices, remain a constant element of children's dietary intake.

Strengths and Limitations

This is the first study in a middle school setting to use a natural experimental, repeat cross-sectional design before and after the implementation of the standards to evaluate the impact both at lunchtime and in total diet [49]. A limitation of this approach is attributing causality [24]. National implementation of the food and nutrient-based standards in primary, middle and secondary schools prevented the use of a stronger study design with a control group and prospective follow-up of individual children [24]. This study was limited to the North East of England, so, findings may not be generalisable [24]. Socio-economic status was estimated using IMD, which does not measure individual levels of deprivation, and is therefore subject to potential misclassification bias [50]. We used identical prospective dietary data collection methods at both time points to ensure consistency. The data collection method relied on self-report and was potentially subject to misreporting [51]. We collected two three-day periods of dietary data to limit this bias.

Conclusions and implications

The school environment offers an opportunity to influence dietary intake. Yet, our findings have shown limited evidence of the food and nutrient-based standards affecting total diet in this age group, which is in contrast to the results among younger children [24]. Reasons for this may be a reduction in the proportion of children consuming a school lunch, less than full compliance with the food and nutrient-based standards, or individual food choice. School lunches have potential to improve

children's dietary intake but only if they are consumed. This study found a decrease in school lunch take-up which suggests the importance of addressing the wider social aspects of overcrowding, noise and queues in school dining rooms [12,14,27] to provide an attractive environment conducive to healthy eating. Other factors may also be associated with a decrease in school lunch take-up. The standards limit the frequency of serving of certain foods and also restrict what food and drink can be served. A process evaluation undertaken parallel to this study highlighted that parents of younger children (4–7 y olds) supported the restriction of food choice. However, there was more 'ambivalence' in the parents of middle school children (11–12 y olds) for whom personal preference was an important issue. In the 11–12 y olds some parents were more concerned about value for money and that children had enough to eat, therefore, some parents preferred to give their children a home-packed lunch as this was considered cheaper and 'less risky'. [27] This may be reflected in the lower decline of take-up in children from more deprived families who would be more likely to be in receipt of free school meals.

We noted variation in provision between schools and not all of the middle schools that participated in this study were fully compliant with the standards. For policy changes to be implemented effectively in schools and achieve the potential impact, support needs to be available for all stakeholders, including catering suppliers, head teachers and school catering staff. Policies affecting the provision of school food should also take account of the views of students using these facilities, [12,14] both at policy development and implementation stages. Strategies to support and guide food choice by pupils remains important; on a positive note children consuming school lunches were shown to eat a lower per cent energy from fat, saturated fat, NMES and sodium than those consuming home-packed lunches, but fewer micronutrients, which is a cause for concern. This study shows improvements are needed in the nutritional content of both school lunches and home-packed lunches. Our findings highlight a persistent need to improve dietary intake in this age group both at school and throughout the day. Across the socio-economic spectrum, children's consumption of saturated fat and NMES remain above the recommended limits, while micronutrients remain below. In 1984, Hackett et al. noted the need for a focus

on nutrient density in children's diets due to falling energy intakes [33]. This remains relevant today. These findings reiterate the importance of considering the influence of the wider environment in this age group, and also, the need for both policy and societal approaches.

Acknowledgments

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Author Contributions

Conceived and designed the experiments: AJA MW JNSM SS. Performed the experiments: SS JD. Analyzed the data: SS JNSM ES. Contributed to the writing of the manuscript: SS JD ES JNSM MW AJA.

References

- HM Government (2007) PSA Delivery Agreement 12: Improve the health and wellbeing of children and young people. London: The Stationery Office.
- Department of Health (2004) Choosing health: making healthy choices easier. London: Department of Health.
- Department of Health (2005) Choosing a Better Diet: a food and health action plan. London: Department of Health.
- Stamatakis E, Wardle J, Cole TJ (2010) Childhood obesity and overweight prevalence trends in England: evidence for growing socioeconomic disparities. *Int J Obes* 34: 41–47.
- Rokholm B, Baker J, Sorensen T (2010) The levelling off of the obesity epidemic since the year 1999—A review of evidence and perspectives. *Obes Rev* 11: 835–846.
- The Health and Social Care Information Centre (2012) National Child Measurement Programme: England, 2011/2012 school year. London: Department of Health.
- Stamatakis E, Zaninotto P, Falaschetti E, Mindell J, Head J (2010) Time trends in childhood and adolescent obesity in England from 1995 to 2007 and projections of prevalence to 2015. *J Epidemiol Community Health* 64: 167–174.
- Craigie A, Matthews JNS, Rugg-Gunn AJ, Lake A, Mathers JC, et al. (2009) Raised adolescent body mass index predicts the development of adiposity and a central distribution of body fat in adulthood: A longitudinal study. *Obes Facts* 2: 150–156.
- Craigie A, Lake A, Kelly S, Adamson AJ, Mathers JC (2011) Tracking of obesity-related behaviours from childhood to adulthood: A systematic review. *Maturitas*.doi:10.1016/j.maturitas.2011.08.005.
- Bates B, Lemox A, Prentice A, Bates C, Swan G (2008/9-2010/11) National Diet and Nutrition Survey: Headline results from Years 1, 2 and 3 (combined) of the Rolling Programme. Available: <http://transparency.dh.gov.uk/2012/07/25/ndns-3-years-report/> Accessed 22nd Jan 2014.
- Fletcher ES, Rugg-Gunn AJ, Matthews JNS, Hackett A, Moynihan PJ, et al. (2004) Changes over 20 years in macronutrient intake and body mass index in 11- to 12-year old adolescents living in Northumberland. *Br J Nutr* 92: 321–333.
- Wills W, Milburn-Backett K, Gregory S, Lawton J (2005) The influence of the secondary school setting on the food practices of young teenagers from disadvantaged backgrounds in Scotland. *Health Educ Res* 20: 458–465.
- Stead M, McDermott L, Mackintosh A, Adamson AJ (2011) Why healthy eating is bad for young people's health: identity, belonging and food. *Soc Sci Med* 72: 1131–1139.
- Fletcher A, Jamal F, Fitzgerald-Yau N, Bonell C (2013) We've got some underground business selling junk food: Qualitative evidence of the unintended effects of English school food policies. *Sociology*.doi:10.1177/0038038513500102.
- The Education (Nutritional Standards and Requirements for School Food) (England) (Amendment) Regulations 2008 Available: http://www.opsi.gov.uk/si/si2008/pdf/uksi_20081800_en.pdf Accessed 28th Mar 2012.
- School Food Trust: A Guide to introducing the Government's food-based and nutrient-based standards for school lunches. Available: http://www.childrensfoodtrust.org.uk/assets/sft_nutrition_guide.pdf Accessed September 2014.
- Rogers IS, Ness AR, Hebditch K, Jones LR, Emmett PM (2007) Quality of food eaten in English primary schools: school dinners vs packed lunches. *Eur J Clin Nutr* 61: 856–864.
- Rees GA, Richards CJ, Gregory J (2008) Food and nutrient intakes of primary school children: a comparison of school meals and packed lunches. *J Hum Nutr Diet* 21: 420–427.
- Evans CEL, Cleghorn CL, Greenwood DC, Cade JE (2010) A comparison of British school meals and packed lunches from 1990 to 2007: meta-analysis by lunch type. *Br J Nutr* 104: 474–487.
- Haroun D, Harper C, Wood L, Nelson M (2010) The impact of the food-based and nutrient-based standards on lunchtime food and drink provision and consumption in primary schools in England. *Public Health Nutr* 14: 209–218.
- Golley R, Pearce J, Nelson M (2010) Children's lunchtime food choices following the introduction of food-based standards for school meals: observations from six primary schools in Sheffield. *Public Health Nutr* 14: 271–278.
- Harrison F, Jennings A, Jones A, Welch A, van Shuijs E, et al. (2011) Food and drink consumption at schooltime: the impact of lunch type and contribution to overall intake in British 9-10-year-old children. *Public Health Nutr* doi:10.1017/S136890011002321.
- Pearce J, Harper C, Haroun D, Wood L, Nelson M (2011) Key differences between school lunches and packed lunches in primary schools in England in 2009. *Public Health Nutr* 14: 1507–1510.
- Spence S, Delve J, Stamp E, Matthews JNS, White M, et al. (2013) The Impact of Food and Nutrient-Based Standards on Primary School Children's Lunch and Total Dietary Intake: A Natural Experimental Evaluation of Government Policy in England. *PLoS One* 8 (10): e78298.doi:10.1371/journal.pone.0078298.
- Prynce C, Handford C, Dunn V, Bamber D, Goodyer I, et al. (2011) The quality of midday meals eaten at school by adolescents: school lunches compared with packed lunches and their contribution to total energy and nutrient intakes. *Public Health Nutr* doi:10.1017/S136890011002205.
- Stevens L, Nicholas J, Wood L, Nelson M (2011) Secondary school food survey 2. School lunches versus packed lunches. Available: <http://www.childrensfoodtrust.org.uk/research/schoolfoodstandardsresearch/secondaryschoolfoodsurvey/secondary-school-meals-versus-packed-lunches-2011> Accessed 4th Feb 2014.
- Adamson AJ, White M, Stead M, Delve J, Stamp E, et al. (2011) The process and impact of change in the school food policy on food and nutrient intake of children aged 4–7 and 11–12 years both in and out of school: a mixed methods approach. Available: http://phrc.lshtm.ac.uk/papers/PHRC_B5-07_Final_Report.pdf.
- Hackett AF, Rugg-Gunn AJ, Appleton DR, Parkin JM, Eastoe JE (1984) A 2-year longitudinal study of dietary intake in relation to the growth of 405 English children initially aged 11–12 years. *Ann Hum Biol* 11: 545–553.
- Hackett AF, Rugg-Gunn AJ, Appleton DR (1983) Use of a dietary diary and interview to estimate the food intake of children. *Human Nutr: Appl Nutr* 37: 293–300.
- Adamson AJ, Rugg-Gunn AJ, Butler TJ, Appleton DR, Hackett AF (1992) Nutritional intake, height and weight of 11–12-year-old Northumbrian children in 1990 compared with information obtained in 1980. *Br J Nutr* 68: 543–563.
- Adamson AJ, Rugg-Gunn AJ, Butler TJ, Appleton DR (1996) The contribution of foods from outside the home to the nutrient intake of young adolescents. *J Hum Nutr Diet* 9: 55–68.
- Rugg-Gunn AJ, Fletcher ES, Matthews JNS, Hackett AF, Moynihan PJ, et al. (2007) Changes in consumption of sugars by English adolescents over 20 years. *Public Health Nutr* 10: 354–363.
- Hackett AF, Rugg-Gunn AJ, Appleton DR, Eastoe JE, Jenkins GN (1984) A 2-year longitudinal nutritional survey of 405 Northumberland children initially aged 11.5 years. *Br J Nutr* 51: 67–75.
- Hackett AF, Appleton DR, Rugg-Gunn AJ, Eastoe J (1985) Some influences on the measurement of food intake during a dietary survey of adolescents. *Hum Nutr: Applied Nutr* 39A: 167–177.
- Foster E, Hawkins A, Adamson AJ (2010) Young Person's Food Atlas. London: Food Standards Agency.
- Food Standards Agency (2002) McCance and Widdowson's the Composition of Foods, Sixth Summary Edition. Cambridge: The Royal Society of Chemistry.
- Kitchen S, Poole E, Reilly N (2013) School food: Head Teachers' and Senior Managers' Perceptions Survey. London: Department of Education.
- Communities and Local Government Indices of Deprivation 2007. Available: <http://webarchive.nationalarchives.gov.uk/+http://www.communities.gov.uk/communities/neighbourhoodrenewal/deprivation/deprivation07/> Accessed 30th June 2011.
- Department of Health (1991) Dietary Reference Values for Food Energy and Nutrients for the United Kingdom. London: HMSO.
- Nelson M, Nicholas J, Wood L, Riley K, Russell S (2011) Statistical release: Take up of school lunches in England 2010–2011. Available: <http://www.childrensfoodtrust.org.uk/research/annual-surveys> Accessed 4th Feb 2014.
- Pearce J, Wood L, Nelson M (2012) Lunchtime food and nutrient intakes of secondary-school pupils: a comparison of school lunches and packed lunches following the introduction of mandatory food-based standards for school lunch. *Public Health Nutr* 16: 1126–1131.
- Stevens L, Nicholas J, Wood L, Nelson M (2012) School lunches v. packed lunches: a comparison of secondary schools in England following the introduction of compulsory food standards. *Public Health Nutr* 16: 1037–1042.

School Food Standards and Adolescent's Nutrient Intake

43. Hur I, Burgess-Champoux T, Reicks M (2011) Higher Quality Intake from School Lunch Meals Compared with Bagged Lunches. *Infant, Child, & Adolesc Nutr* 3: 70-75.
44. Taylor J, Hernandez K, Caiger J, Giberson D, MacLellan D, et al. (2012) Nutritional quality of children's school lunches—differences according to food source. *Public Health Nutr* 15: 2259-2264.
45. Pearce J, Wood L, Stevens L (2013) Portion weights of food served in English schools: have they changed following the introduction of nutrient-based standards? *J Hum Nutr Diet* 26: 553-562.
46. Fung C, McIsaac JLD, Kuhle S, Kirk SFL, Veugelers PJ (2013) The impact of a population-level school food and nutrition policy on dietary intake and body weights of Canadian children. *Prev Med* 57: 934-940.
47. Bates B, Lennox A, Bates C, Swan G (2011) National Diet and Nutrition Survey: Headline results from years 1 and 2 (combined) of the Rolling Programme 2008/9-2009/10. London: Department of Health.
48. Gregory J, Lowe S (2000) National Diet and Nutrition Survey: young people aged 4 to 18 years. London: HMSO.
49. Craig P, Cooper C, Gunnell D, Haw S, Lawson K, et al. (2012) Using natural experiments to evaluate population health interventions: new Medical Research Council guidance. *J Epidemiol Community Health* 66: 1182-1186.
50. Pockett R, Adlard N, Carroll S, Rajoriya F (2011) Paediatric hospital admissions for rotavirus gastroenteritis and infectious gastroenteritis of all causes in England: an analysis of correlation with deprivation. *Curr Med Res Opin* 27: 777-784.
51. Livingstone M, Robson P, Wallace J (2004) Issues in dietary intake assessment of children and adolescents. *Br J Nutr* 92: S213-S222.

5.4 Paper IV A repeat cross-sectional study examining the equitable impact of nutritional standards for school lunches in England in 2008 on the diets of 4-7y olds across the socio-economic spectrum.

RESEARCH ARTICLE

Open Access

A repeat cross-sectional study examining the equitable impact of nutritional standards for school lunches in England in 2008 on the diets of 4-7y olds across the socio-economic spectrum

Suzanne Spence^{1,2}, John NS Matthews³, Martin White^{1,2,4} and Ashley J Adamson^{1,2,4*}

Abstract

Background: The 2008 nutritional standards for primary school lunch in England improved nutritional content. The impact on socio-economic inequalities is unknown. We examine the impact of the nutritional standards on children's nutrient intake at lunchtime and in total diet by level of deprivation.

Methods: We conducted cross-sectional studies in 12 English primary schools before and after legislation. Dietary intake was recorded for 4-7y olds using a validated, prospective four-day food diary. Socio-economic status was estimated using the Index of Multiple Deprivation; three groups of approximately equal sizes were created. Linear, mixed-effect models explored the effect of year, lunch type (school or home-packed lunch), level of deprivation and the interaction(s) between these factors on children's diets.

Results: 368 and 624 children participated in 2003-4 and 2008-9 respectively. At lunchtime, between 2003-4 and 2008-9, the increase in non-starch polysaccharide (NSP) intake was larger in the least compared to the most deprived group (difference in mean change 0.8 mg; 95% CI 0.4, 1.3). There were similar differences in mean changes for iron (0.3 mg; 0.2, 0.4) and zinc (0.3 mg; 0.1, 0.5). In total diet, differential effects were observed for NSP, iron and zinc; we found no evidence these changes were associated with lunch type. Lunch type was associated with changes in per cent energy from non-milk-extrinsic sugars (NMES) and vitamin C. Per cent energy from NMES was lower and vitamin C intake higher in school lunches in 2008-9 compared with 2003-4. The corresponding differences in home-packed lunches were not as marked and there were subtle but statistically significant effects of the level of deprivation.

Conclusions: By 2008-9, NMES at lunchtime and in total diet was lower for children consuming a school lunch; this change was equitable across the deprivation groups. Vitamin C intake increased more for children in the most deprived group, narrowing the socio-economic inequality. A range of significant differential effects of the nutritional standards were observed and important socio-economic inequalities in dietary intake remain. Additional interventions to promote equitable nutrition in children are needed to support legislative measures and maximise their impact.

Keywords: School lunch, Packed lunch, Children, Inequalities, Nutrition

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Background

Dietary intake has an important influence on child health [1,2] but there remain important socio-economic inequalities [3]. Identifying solutions has proved challenging [4-6] because children's diets are influenced by many individual, social and environmental factors [1,7].

The school environment has long been considered important in the promotion of child health nationally and internationally [8,9], and there is increasing evidence for the effectiveness of school interventions to tackle obesity [10-12]. Schools are important environments for dietary interventions, due to the time children spend in school, exposure to school food [12] and their potential to influence food choice and behaviours [13-15] across the socio-economic spectrum [16].

Primary schools in England have been required to comply with legislation detailing specific food- and nutrient-based standards for school food since September 2008 [17,18]. This was in response to a number of factors; for example, national surveys of school lunch in primary and secondary schools [19,20] and a media broadcast in April 2005 "*Jamie's School Dinners*" [21] highlighted the poor nutritional content of school lunch. The introduction of these standards to school lunches aimed to improve children's dietary intake at lunchtime. Several studies have reported improvements in children's mean nutrient intake from a school lunch associated with the introduction of the food and nutrient-based standards [22,23]. In a recent study we examined the impact of this legislation on children's mean intake at lunchtime and in total dietary intake. Our key findings showed a widening difference in mean macro- and micronutrient intakes between a school and home-packed lunch, with the average school lunch providing a 'healthier' option. Improvements were also found for children consuming a school lunch in their mean total dietary intake [24]. However, it is not known if the changes to school lunch impact equitably across the socio-economic spectrum, for example, does improving food provision at school lunch inadvertently increase the difference in children's mean nutrient intake due to individual food choice? As the standards focus only on school lunch, what is the impact of home-packed lunch on nutrient intake across the socio-economic spectrum? With the recent UK Government announcement that all children aged 4-7 years in England will be entitled to a free school lunch from September 2014 [25], understanding further the impact of school lunch on children's diets across the socio-economic spectrum is important.

The primary aim of this paper is to examine the impact of the 2008 food and nutrient-based standards on socio-economic inequalities in food consumed at lunchtime and in total diet in children aged 4-7 years. A secondary aim is to examine the change in school lunch take-up across deprivation groups.

Methods

Details of the methods have been previously reported [24,26]; a brief summary is provided below.

Setting and participants

Cross-sectional studies were undertaken in primary schools in Newcastle, North East England over two academic years: 2003-4, $n = 16$ (before) and 2008-9, $n = 13$ (after implementation of the legislation). The 2003-4 data were collected as part of a previous study [27] and used as baseline. The analysis presented includes data collected from 12 schools that participated in both 2003-4 and 2008-9. This was a key aspect for this study; to recruit the same schools for which we had dietary data pre-implementation of the policy to enable us to compare nutrient intake pre and post-implementation. Schools were originally selected in 2003-4 using the free school meal index [28] as a proxy measure for the level of deprivation in the school population to seek a balance across the socio-economic spectrum. The free school meal index indicates the percentage of children in a school eligible for free school meals. The schools that participated were selected to cover a range of deprivation areas in Newcastle; Newcastle consists of 26 wards with varying levels of deprivation (Index of Multiple Deprivation (IMD) range: 7.56 to 75.57), the schools that participated were from 9 wards with a range in IMD: 7.56 to 73.92. The same schools were invited to participate in 2008-9; only after consent by Head teachers were schools included. After parental consent individual level IMD was determined from postcodes and used in the analysis. All children in reception, year 1 and 2 were eligible to participate. Parents provided informed, written consent prior to children participating and ethical approval was granted by Newcastle University Ethics Committee (reference 000011/2007).

Data

Dietary

We used identical dietary data collection methods in 2003-4 and 2008-9. Using a previously validated prospective four-day food diary (the *Food Assessment in Schools Tool (FAST)*) [24,27], we recorded children's dietary intake over three consecutive week days and one weekend day (Wednesday to Saturday inclusive). Parents received written instructions on how to complete the diary at home. At each school a team of trained observers and the study nutritionist recorded dietary intake. Foods were categorised into 'school', 'home-packed lunch', and 'food consumed at home'. Dietary coding for nutritional composition was based on McCance and Widdowson's Integrated Composition of Food Dataset [29]. The specific macro- and micronutrients examined in this paper relevant to the nutrient-based standards are: energy, per cent energy from fat, saturated fat and non-milk intrinsic

sugars (NMES), and absolute amounts of non-starch polysaccharide (NSP), iron, zinc and vitamin C. Children's mean nutrient intakes were compared to the nutrient-based standards [30] at lunchtime and to dietary reference values [31] for total diet.

School lunches were coded using school lunch recipes, made available by relevant primary school catering services.

Socio-economic

Socio-economic status (SES) was estimated using the English Index of Multiple Deprivation (IMD) 2007, matched to full (7 digit) postcodes at the Lower Layer Super Output area level for individual children's home address [32]. IMD is a composite measure of deprivation including seven domains; income, employment, health and disability, education, skills and training, barriers to housing and services, crime and living environment [32]. This enables areas to be ranked by relative deprivation [32]. The IMD scores were then categorised into three groups of approximately equal size for the analyses: group 1 included children living in the 20% least deprived areas, group 2 children living in the 60% mid-deprived areas, and group 3 included children living in the 20% most deprived areas.

Statistical analysis

The analyses examined the change in school lunch take up and children's mean macro- and micronutrient intakes at lunchtime and in total diet.

Logistic regression was used to examine the change in school lunch take up by year and level of deprivation. The analysis examined the effect of year (before and after legislation), a child's lunch type (school or home-packed lunch), level of deprivation (least, mid and most deprived groups), as factors and the interaction(s) between these factors. We used a linear mixed effect model, with year, lunch type, level of deprivation and gender taken as fixed effects. Potential correlation between responses within the same school or child were accommodated by fitting random effects for each. The models were fitted using 'lme' in R (version 2.14.0). Data for vitamin C were log-transformed because of skewness and geometric means are reported.

Variables

Main outcome measures were change in mean daily intakes of macro- and micronutrients in school and home-packed lunch, and total diet by level of deprivation. Macro- and micronutrients reported in this paper are: energy (kcal), per cent energy from fat, saturated fat and non-milk extrinsic sugars, non-starch polysaccharides (g), iron (mg), zinc (mg) and vitamin C (mg). Predictors were year, lunch type and level of deprivation.

Results

Participants and school lunch take up in 2003–4 and 2008–9

The analyses included 368 children in 2003–4 (63% of those consenting) and 624 (81% of those consenting) in 2008–9; reasons for exclusion are shown in Figure 1. There were similar numbers of boys and girls participating in 2003–4 (male $n = 181$ (49%); female $n = 187$ (51%)) and 2008–9 (male $n = 317$ (51%); female $n = 307$ (49%)), mean age was 5.8y in 2003–4 and 6.1y in 2008–9. We found no statistically significant difference in the level of deprivation for children included in the analysis in 2003–4 and 2008–9 (mean IMD 27.0 and 26.1 respectively, $p = 0.50$) (Table 1).

Between 2003–4 and 2008–9, there was a decrease in the percentage of children consuming a school lunch across all deprivation groups ($p = 0.005$; Table 2); the odds ratio (OR) for consuming a school lunch in 2008–9 compared with 2003–4 OR was 0.68 (95% CI 0.52 to 0.88). Children in the most deprived group were more likely to have a school lunch compared with those in the mid and least deprived groups ($p < 0.001$, OR 1.41, 1.23 to 1.62). There was no evidence of any interaction between year by level of deprivation ($p = 0.38$), indicating no change in the relationship between level of deprivation and school lunch take-up over time.

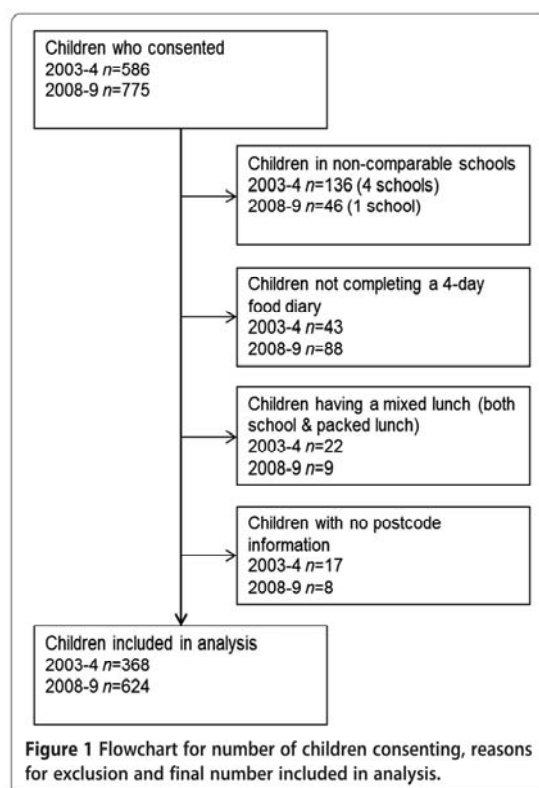


Table 1 Study sample characteristics

	2003-4		2008-9	
	<i>(n = 368)</i>		<i>(n = 624)</i>	
	<i>(Male = 181; Female = 187)</i>		<i>(Male = 317; Female = 307)</i>	
	Mean	SD	Mean	SD
Age	5.8	0.7	6.1	0.9
Index of Multiple Deprivation	27.0	20	26.1	21

Children's mean nutrient intake**Lunchtime**

Level of deprivation Children in the least deprived group had a higher mean energy intake (520 kcals) at lunchtime compared with those in the mid and most deprived groups (mid = 487 kcals, least deprived = 492 kcals; $p = 0.002$), regardless of year or lunch type.

Year by level of deprivation interaction We found no evidence of a year by level of deprivation interaction in relation to children's mean intake of per cent energy from fat ($p = 0.7$), saturated fat ($p = 0.7$), non-milk-extrinsic sugars (NMES) ($p = 0.4$) or vitamin C intake ($p = 0.6$). In 2003-4, there was little difference in children's mean NSP, iron or zinc intake between deprivation groups (Figure 2 and Table 3). Between 2003-4 and 2008-9, mean NSP intake increased in all deprivation groups; the mean change was greatest in the least deprived group (year by level of deprivation interaction, $p = 0.001$; Figure 2). Between 2003-4 and 2008-9, mean iron and zinc intake increased in the least and mid-deprived groups, but there was little change in the most deprived group (year by level of deprivation interaction, $p = 0.0004$ and $p = 0.002$ respectively; Figure 2 and Table 3). These changes were not associated with lunch type.

Lunch by level of deprivation We found no evidence of any lunch by level of deprivation interactions on the nutrients examined.

Although children in the least deprived group had a higher mean NSP, iron and zinc intake, mean intakes remained below the nutrient-based standards for school lunch of 4.2 g, 3 mg and 2.5 mg respectively [30],

Table 2 Number (percentage) of children consuming a school lunch by year and level of deprivation

Level of deprivation:	2003-4	2008-9
	<i>n (%)</i>	<i>n (%)</i>
Least deprived	43 (54)	81 (42)
Mid deprived	90 (54)	105 (50)
Most deprived	89 (74)	132 (60)
All children	222 (60)	318 (51)

regardless of whether they consumed a school or home-packed lunch.

Total diet

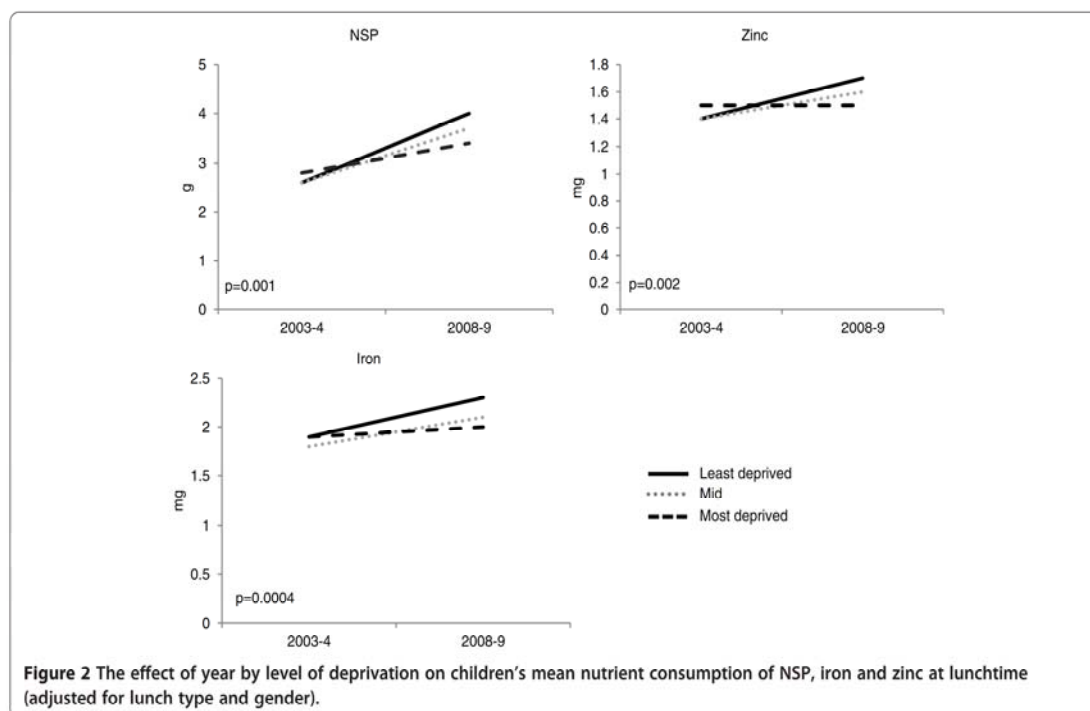
Year by level of deprivation interaction Between 2003-4 and 2008-9, there was a decrease in mean energy intake in total diet in all deprivation groups (year by level of deprivation interaction, $p = 0.001$; Figure 3); this decrease was smallest in the least deprived group (-73 kcals) and largest in the most deprived (-253 kcals).

Children's mean per cent energy from fat and saturated fat both improved (decreased) from 2003-4 and 2008-9, but there was no evidence of a year by level of deprivation interaction ($p = 0.4$ and $p = 0.06$ respectively) (Table 4). In 2003-4 and 2008-9, children's mean intake of per cent energy from fat was below the recommended guideline level of 35%, but above the recommended level of 11% for saturated fat [31].

In 2003-4, there was little difference in children's mean NSP, iron and zinc intake between deprivation groups. Between 2003-4 and 2008-9, there was an increase in mean NSP intake in the least and mid-deprived groups, but a decrease in the most deprived group (year by level of deprivation interaction, $p = 0.014$; Figure 3). Between 2003-4 and 2008-9, there was little change in children's mean iron and zinc intake in the least and mid-deprived groups, but a fall in intake for children in the most deprived group (year by level of deprivation interactions: $p = 0.002$ and 0.007 respectively) (Figure 3). These changes were not associated with lunch type. Across all levels of deprivation, children's mean iron intake met the reference nutrient intake of 6.1 mg/day; mean zinc intake was below the recommended 6.5 mg/day [31].

Level of deprivation, year and lunch type interaction

In total diet a significant interaction between level of deprivation, year and lunch type was found for two nutrients: per cent energy from NMES ($p = 0.047$) and vitamin C ($p = 0.035$) (Figure 4). In 2003-4, children from across the deprivation groups who ate a school lunch had a lower per cent energy (%E) from NMES compared with children who ate a home-packed lunch (Figure 4 and Table 5). The difference between a school and home-packed lunch in the least deprived group was



0.5%E and in the most deprived group 2.1%E. Between 2003–4 and 2008–9, per cent energy NMES intake from school lunch fell and children who ate a school lunch continued to have a lower intake. For children who ate a home-packed lunch, mean intake remained similar between 2003–4 and 2008–9 in the least deprived group

(mean change -0.3%) but fell in the most deprived group (-3.1%) (difference in mean change -2.8% ; 95% CI -5.5 to -0.1). This led to an improvement in mean percent energy from NMES in all deprivation groups for children consuming a school lunch, but a disparity for children consuming a home-packed lunch with higher levels in

Table 3 Lunchtime: the effect of year by level of deprivation on children's mean nutrient intake compared with nutrient-based standards [30]

Nutrient	Standard	Level of deprivation	2003-4 Mean*	2008-9	[2008-9] - [2003-4] (Mean change) 95% confidence interval	p-value for interaction [†] (year by level of deprivation)
NSP [‡] (g)	Min 4.2	Least	2.6	4.0	(1.4) 1.1,1.8	0.001
		Mid	2.6	3.7	(1.1) 0.9,1.4	
		Most	2.8	3.4	(0.6) 0.3,0.9	
Iron (mg)	Min 3	Least	1.9	2.3	(0.4) 0.3,0.6	0.0004
		Mid	1.8	2.1	(0.3) 0.2,0.4	
		Most	1.9	2.0	(0.1) -0.1,0.2	
Zinc (mg)	Min 2.5	Least	1.4	1.7	(0.3) 0.2,0.4	0.002
		Mid	1.3	1.6	(0.3) 0.1,0.4	
		Most	1.5	1.5	(0.0) -0.1,0.1	
Vitamin C (mg)*	Min 10.5	Least	16.5	33.4	(0.49) 0.40,0.61	0.64
		Mid	14.2	32.6	(0.44) 0.37,0.51	
		Most	14.3	31.9	(0.45) 0.37,0.54	

*Arithmetic means are reported, except for vitamin C (highly skewed) where geometric means and ratios are given.

[†]p-value for interaction derived from a linear mixed effects model with random term for schools.

[‡]NSP (non-starch polysaccharide).

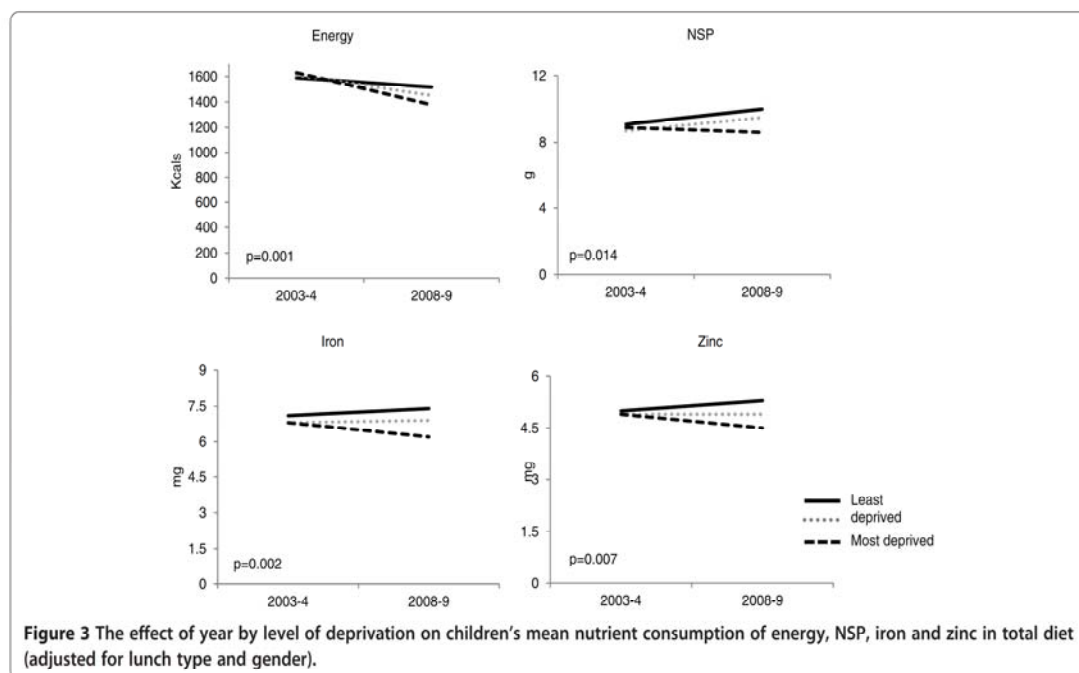


Table 4 Total diet: the effect of year by level of deprivation on children's mean nutrient intake compared with DRV/RNI's [31]

Nutrient	DRV/RNI*	Level of deprivation	2003-4 Mean	2008-9 Mean	[2008-9] - [2003-4] (Mean change) 95% confidence interval	p-value for interaction† (year by level of deprivation)
Energy (kcal)	±	Least	1589	1516	(-73) -143,-2,2	0.001
		Mid	1612	1450	(-162) -216,-107	
		Most	1630	1377	(-253) -315,-121	
% E fat‡	35	Least	33.3	31.5	(-1.8) -2.8,-0.8	0.4
		Mid	34.5	31.5	(-3.0) -3.4,-1.9	
		Most	34.1	31.9	(-2.2) -3.0,-1.4	
% E saturated fat‡	11	Least	14.4	13.8	(-0.6) -1.2,0.0	0.06
		Mid	14.8	13.4	(-1.4) -1.8,-0.9	
		Most	14.1	13.4	(-0.7) -1.2,-0.2	
NSP* (g)	-	Least	9.1	10.0	(0.9) 0.3,1.6	0.014
		Mid	8.7	9.5	(0.8) 0.3,1.3	
		Most	8.9	8.6	(-0.3) -0.9,0.4	
Iron (mg)	6.1	Least	7.1	7.4	(0.3) -0.7,0.1	0.002
		Mid	6.8	6.9	(0.1) -0.4,0.2	
		Most	6.8	6.2	(-0.6) -1.0,-0.3	
Zinc (mg)	6.5	Least	5.0	5.3	(0.3) -0.1,0.5	0.007
		Mid	4.9	4.9	(0.0) -0.2,0.2	
		Most	4.9	4.5	(-0.4) -0.6,-0.1	

*Dietary reference value/Reference nutrient intake [31].

†p-value for interaction derived from a linear mixed effects model with random term for schools.

‡Boy (1715 kcal), Girl (1545 kcal).

§% E fat/saturated fat (per cent energy derived from fat/saturated fat).

*NSP (non-starch polysaccharides).

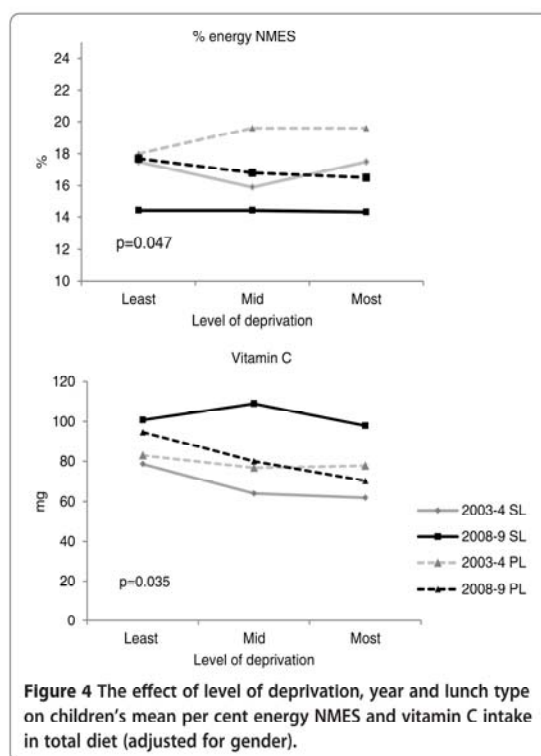


Figure 4 The effect of level of deprivation, year and lunch type on children's mean per cent energy NMEs and vitamin C intake in total diet (adjusted for gender).

the least deprived group. Across all groups, children's mean per cent energy NMEs remained above the dietary reference value of 11% in their total diet [31].

In 2003–4, children who ate a school lunch had a lower mean vitamin C intake in all deprivation groups compared with children who ate a home-packed lunch (Figure 4 and Table 5). The difference between children having a school and home-packed lunch in the least deprived group was –4.3 mg and in the most deprived group –15.9 mg. In

2008–9, children who ate a school lunch had a higher mean vitamin C intake, which was similar in the least and most deprived groups; the increase was smaller in the least deprived group (22.2 mg) compared with the most deprived group (36 mg; Figure 4). For children who ate a home-packed lunch, mean intake increased in the least deprived group (11.7 mg) but fell in the most deprived group (–7.5 mg), leading to a wider difference between lunch type in the least deprived group (Figure 4). Across the deprivation groups, children's mean vitamin C intake met the reference nutrient intake of 30 mg/day in 2003–4 and 2008–9 [31].

Discussion

Summary of key findings

In 2008–9, following legislation to introduce nutritional standards for primary school lunches in England, school lunch take-up decreased across all deprivation groups. Between 2003–4 and 2008–9, our findings show a widening difference by level of deprivation in mean NSP, iron and zinc intakes at lunchtime and in total diet, but we found no evidence this was influenced by lunch type. In total diet, year, lunch type and level of deprivation were found to influence children's mean per cent energy from NMEs and vitamin C, and there was a widening difference by lunch type. For children consuming a school lunch per cent energy from NMEs reduced to similar levels for all the deprivation groups thereby narrowing inequalities, whereas for children consuming a home-packed lunch, the decrease was less marked in the least deprived group. For children consuming a school lunch children's vitamin C intake was now similar, leading to a narrowing of socio-economic inequalities; in contrast, for children consuming a home-packed lunch there was a widening of socio-economic inequalities, with children from the least deprived families now having a substantially higher intake.

Table 5 Total diet: the effect of level of deprivation, year and lunch type on per cent energy NMEs and mean vitamin C intake

Nutrient	Level of deprivation	School lunch			Packed lunch			p-value for interaction [†]
		2003-4	2008-9	[2008-9] – [2003-4]	2003-4	2008-9	[2008-9] – [2003-4]	
% energy NMEs	Least	17.5	14.4	(–3.1) –4.9,–1.3	18.0	17.7	(–0.3) –2.1,1.5	0.047
	Mid	15.9	14.4	(–1.5) –2.9,–0.1	19.6	16.8	(–2.8) –4.2,–1.4	
	Most	17.5	14.3	(–3.2) –4.5,–1.8	19.6	16.5	(–3.1) –5.1,–1.1	
Vitamin C (mg)*	Least	78.6	100.8	(0.8) 0.7,0.9	82.9	94.6	(0.9) 0.7,1.1	0.035
	Mid	64.0	109.1	(0.6) 0.5,0.7	76.8	80.0	(1.0) 0.8,1.1	
	Most	61.9	97.9	(0.6) 0.5,0.7	77.8	70.3	(1.1) 0.9,1.3	

*Arithmetic means are reported, except for vitamin C (highly skewed) where geometric means and ratios are reported.

[†]p-value for 3-way interaction derived from a linear mixed effects model with random term for schools.

Strengths and limitations

We used identical dietary data collection methods in 2003–4 and 2008–9 to avoid introducing measurement bias [20]. Key strengths of this dietary data collection method are that it was previously validated, is easy for parents to use and all food consumed was observed [27]. This limited the problems associated with dietary self-report methods in this age-group.

Previous studies [21,22] have only collected data post-legislation with no baseline against which to assess the impact of change at lunchtime or in total diet. This is the first study to use a natural experimental [33], repeat cross-sectional design to evaluate the 2008 legislation to improve the nutritional content of school food in England, and to analyse differential impact according to socio-economic status. A limitation of such a design is attributing causality. In addition, this study cannot account for other secular changes that may be associated with changes in diet such as national campaigns or the economic climate. However, we have reported change in intake from school lunch which can be attributed to a change in school food policy. As previously reported, national implementation of the food- and nutrient-based standards imposed time constraints that prevented the use of a stronger study design with prospective follow-up of individual children [23]. This study was also limited to 12 primary schools in Newcastle in the North East of England, so, findings may not be generalisable.

For children consuming a school lunch we had no information on free or paid school lunch at an individual level; this could have been advantageous for a more detailed analysis examining the impact of lunch type (free and paid school lunch) on children's total diet.

A limitation of using IMD is that it does not measure individual socio-economic status, and is therefore subject potentially to the ecological fallacy [34] resulting in misclassification bias [34].

Relationship to previous work

Socio-economic differences in diet are well established; children from more deprived families have been found to consume more energy dense [35–38] and less nutrient-dense foods [39]. Factors such as availability, accessibility [40], parental education and income [37], and cost of foods have been identified as contributing factors [41].

In 2010, a study found a statistically significant difference in children aged 3–17y mean total dietary intake of per cent energy NMES across socio-economic groups; children in the least deprived group consumed less [42]. In our study, between 2003–4 and 2008–9, we found a statistically significant difference between deprivation groups in children's mean total dietary intake of per cent energy NMES. But, in contrast, between 2003–4 and 2008–9, we found children consuming a home-packed

lunch in the least deprived group had a higher mean intake of NMES compared with those in the most deprived group; for children consuming a school lunch there was a similar intake across the deprivation groups. A key difference between these studies was that we examined the impact by lunch type.

Findings from a cross-sectional study using data from the low income diet and nutrition survey collected between 2003 and 2005 did not find any significant differences in energy or nutrient intake between those having a school or home-packed lunch over the whole day [43]. In contrast, we found some evidence that, following the introduction of nutritional standards, between 2003–4 and 2008–9 a child's lunch type had an impact on mean total nutrient intake across levels of deprivation (e.g. per cent energy NMES and vitamin C). However, we were not able to differentiate between children who ate free or paid school lunches, nor limit the analysis to only those children in the most deprived groups, which may explain some of the differences in our findings compared with those previously published [43].

A study in Texas using a pre- (2001–2) and post-policy (2005–6) evaluation in middle schools found reductions in children's mean energy density intake (2.08 kcal/g to 2.17; $p < 0.0001$) in school lunches associated with policy changes [44]. Changes included restrictions to portion sizes of certain foods and drinks, fat content, and frequency of provision [14,44]. In addition, they examined the effect of socio-economic status across schools and observed the greatest changes in schools from the higher and mid-socio-economic areas [44]. In our analysis we did not examine energy density, but we found there was no statistically significant impact of school level variation, and therefore we assessed the impact of deprivation at an individual rather than school level.

What this study adds

There is evidence to suggest that legislation to improve the nutritional content of school lunches has been effective overall [22–24,45,46]. However, this is the first study to examine whether the changes following the 2008 legislation introducing nutritional standards for school lunches in English primary schools had a similar impact on children's diets across levels of deprivation. Our findings for lunchtime suggest that the least deprived children are consuming more nutrient-dense foods from both school lunch and home-packed lunch compared with the most deprived children. Despite this, even for children in the least deprived group, mean NSP, iron and zinc intakes remained below the nutrient-based standards of 4.2 g, 3 mg and 2.5 mg respectively [30]. This highlights children's dietary intake from either a school or home-packed lunch needs to be addressed across the socio-economic spectrum, but most urgently

in children from the most deprived families. We found evidence of widening inequalities in children's mean NSP, iron and zinc intake in total diet; however, there was no evidence lunch type influenced this. Nevertheless, within the limitations of this study there is some evidence that lunch type influences socio-economic inequalities in children's total diet. Legislative changes affecting nutritional content of school lunches were associated with an improvement in per cent energy NMES intake across the deprivation groups; and mean vitamin C intake improved more for the most deprived children, leading to a narrowing of socio-economic inequality.

Implications for policy, practice and further research

Although legislation introducing nutritional standards for school lunches has the potential to improve children's diets, consideration must be given to the possibility that population-based interventions may be differentially effective across socio-economic groups and may have other unintended consequences [47,48].

The findings of this study show where we found evidence of an improvement in children's total dietary intake associated with regulation of the nutritional content of school lunches, for example per cent energy NMES; this benefitted children equally. Although vitamin C intake improved more for the most deprived children, this policy change benefitted children across the social spectrum, and there was a levelling in inequalities. However, we also found that, despite the introduction of legislation to improve the nutritional content of school lunches, there was a widening in inequalities in children's mean NSP, iron and zinc intakes at lunchtime and in total diet. These findings suggest that to achieve its full potential, regulation of nutritional standards for school lunches may need to be supplemented by additional behavioural interventions [49] to improve children's food choice at school lunch, particularly for those in the most deprived groups. Guidance aimed at parents and children's food choices when preparing and consuming home-packed lunches is also required. The finding that children in the least deprived group consuming a home-packed lunch post-legislation have a higher per cent energy from NMES may be due to a higher consumption of products such as smoothies and fruit juices, perceived as 'healthy'; this reinforces the need for parental awareness of nutritional content of products [42].

An unintended outcome of implementing the food and nutrient-based standards may be the subsequent decrease in school lunch take-up. While this decrease may in part be attributable to cost and increasing pressures on family budgets, this study found a decrease in school lunch take-up across levels of deprivation. Free school meals are to be introduced for all children in England aged 4–7 years from September 2014 [25], which is expected to increase

take-up. However, it is not known whether free school meals will be taken up equally by all, or whether this intervention may potentially widen or narrow inequalities in children's diets. Further detailed and robust prospective evaluation is needed. Future policy changes to school food in England, such as the equity impacts of the universal free school lunch, need to consider evaluation outcomes prior to implementation. A whole school approach which goes beyond change in provision and encourages children's food choice may offer a potential solution to inequalities in food choice [50]. The findings from this study suggest that interventions to supplement the regulation of school food, which considers social and economic factors beyond the school environment, are needed to address the complexity of inequalities in children's total dietary intake [51,52].

Abbreviations

FAST: Food Assessment in Schools Tool; IMD: Index of Multiple Deprivation; SES: Socio-economic status; OR: Odds ratio; CI: Confidence interval; NSP: Non-starch polysaccharides; NMES: Non-milk extrinsic sugars; g: Grams; mg: Milligrams; kcals: Kilocalories; %E: Per cent energy.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

AJA conceived the research and, with MW, designed the study. SS and a team of lay observers collected the data. JNSM conducted analyses. SS drafted the manuscript. All authors contributed to data interpretation, commented on drafts and approved the final version. AJA is the study guarantor. All authors read and approved the final manuscript.

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References

1. Foresight: *Tackling obesity: Future Choices- Project Report*. London: The Stationery Office; 2007.
2. Swinburn B, Sacks G, Ravussin E: **Increased food energy supply is more than sufficient to explain the US epidemic of obesity.** *Am J Clin Nutr* 2009, **90**:1453–1456.
3. The Marmot Review: *Fair Society, Healthy Lives*. London: The Marmot Review; 2010.
4. Heitmann BL, Koplan J, Lissner L: **Childhood obesity: successes and failures of preventive interventions.** *Nutr Rev* 2009, **67**(Suppl. 1):S89–S93.
5. Gortmaker SL, Swinburn BA, Levy D, Carter R, Mabry PL, Finegood DT, Huang T, Marsh T, Moodie ML: **Changing the future of obesity: science, policy and action.** *Lancet* 2011, **378**:838–846.
6. Borys JM, Le Bodo Y, Jebb SA, Seidell JC, Summerbell C, Richard D, De Henauw S, Moreno LA, Romon M, Visscher TLS, Raffin S, Swinburn B, Group and the EEN Study: **EPoDE approach for childhood obesity prevention: methods, progress and international development.** *Obesity Rev* 2012, **13**:299–315.
7. Cohen DA, Bhatia R: **Nutrition standards for away-from-home foods in the USA.** *Obesity Rev* 2012, **13**:618–629.
8. WHO: *Technical Report Series No.30 Expert Committee on School Health Services: Report on the First Session*. Geneva: WHO; 1951.
9. WHO *Improving The Lives Of Children And Young People: Case Studies From Europe*. <http://www.euro.who.int/en/publications/abstracts/improving-the-lives-of-children-and-young-people-case-studies-from-europe.-volume-2.-childhood> Accessed Dec 2013.
10. Brown T, Summerbell C: **Systematic review of school based-interventions that focus on changing dietary intake and physical activity levels to prevent childhood obesity: an update to the obesity guidance produced by the National Institute for Health and Clinical Excellence.** *Obesity Rev* 2008, doi:10.1111/j.1467-789X.2008.00515.x.
11. Gonzalez-Suarez C, Worley A, Grimm-somers K, Dones V: **School-based Interventions on childhood obesity - a meta analysis.** *Am J Prev Med* 2009, **37**:418–427.
12. Khambalia AZ, Dickinson S, Hardy LL, Gill T, Baur LA: **A synthesis of existing systematic reviews and meta-analysis of school-based behavioural interventions for controlling and preventing obesity.** *Obesity Rev* 2011, **13**:214–233.
13. Kubik MY, Lytle LA, Hannan PJ, Perry CL, Story M: **The association of the school food environment with dietary behaviors of young adolescents.** *Am J Public Health* 2003, **93**:1168–1173.
14. Cullen KW, Watson KB: **The impact of the Texas Public School Nutrition Policy on student food selection and sales in Texas.** *Am J Public Health* 2009, **99**:706–712.
15. Masse LC, Naiman D, Naylor PJ: **From policy to practice: implementation of physical activity and food policies in schools.** *Int J Behav Nutr Phys Act* 2013, **10**:71. doi:10.1186/1479-5868-10-71.
16. van Cauwenberghe E, Maes L, Spittaels H, van Lenthe F, Brug J, Oppert JM, de Bourdeaudhuij I: **Effectiveness of school-based interventions in Europe to promote healthy nutrition in children and adolescents: systematic review of published and 'grey' literature.** *Br J Nutr* 2010, **103**:781–797.
17. *The Education (Nutritional Standards and Requirements for School Food) (England) (Amendment) Regulations*. 2008. http://www.opsi.gov.uk/si/si2008/pdf/uksi_20081800_en.pdf Accessed March 2012.
18. *School Food Trust Food-Based And Nutrient-Based Standards For School Lunches And Food Other Than Lunches*. http://www.childrensfoodtrust.org.uk/assets/sft_nutrition_guide.pdf Accessed October 2014.
19. Nelson M, Bradbury J, Poulter J, McGee A, Msebele S, Jarvis L: *School Meals in Secondary Schools in England*. London: Department for Education and Skills; 2004.
20. Nelson M, Nicholas J, Suleiman S, Davies O, Prior G, Hall L, Wreford S: *Poulter J School Meals In Primary Schools In England*. London: Department for Education and Skills; 2006.
21. *BBC NEWS Oliver's School Meal Crusade Goes On*, <http://news.bbc.co.uk/1/hi/11/hi/uk/5313882.stm> Accessed April 2013.
22. Haroun D, Harper C, Wood L, Nelson M: **The impact of the food-based and nutrient-based standards on lunchtime food and drink provision and consumption in primary schools in England.** *Public Health Nutr* 2010, **14**:209–218.
23. Golley R, Pearce J, Nelson M: **Children's lunchtime food choices following the introduction of food-based standards for school meals: observations from six primary schools in Sheffield.** *Public Health Nutr* 2010, **14**:271–278.
24. Spence S, Delve J, Stamp E, Matthews JNS, White M, Adamson AJ: **The impact of food and nutrient-based standards on primary school children's lunch and total dietary intake: a natural experimental evaluation of Government Policy in England.** *PLoS One* 2013, **8**(10):e78298. doi:10.1371/journal.pone.
25. *Free School Lunch for every child in infant school*. www.gov.uk/government/news/free-school-lunch-for-every-child-in-infant-school. Accessed December 2013.
26. Adamson AJ, White M, Stead M, Delve J, Stamp E, Matthews JNS, Eadie D, Spence S: *The Process And Impact Of Change In The School Food Policy On Food And Nutrient Intake Of Children Aged 4-7 And 11-12 Years Both In And Out Of School: A Mixed Methods Approach*. 2011. http://phrc.lshtm.ac.uk/papers/PHRC_B5-07_Final_report.pdf.
27. Adamson AJ, Griffiths JM, Carlin LE, Barton KL, Wrieden WL, Matthews JNS, Mathers JC: **FAST: Food Assessment in Schools Tool.** *Proc Nutr Soc* 2003, **62**:84A.
28. *School meals – healthy eating standards: apply for free school meals* www.direct.gov.uk/en/Parents/Schoolslearninganddevelopment/SchoolLife/DG_4016089 Accessed August 2012.
29. Food Standards Agency: *McCance and Widdowson's the Composition of Foods, Sixth*. Summary 6th edition. Cambridge: The Royal Society of Chemistry; 2002.
30. *School Food Trust A Guide to introducing the Government's Food-Based And Nutrient-Based Standards For School Lunches*. http://www.childrensfoodtrust.org.uk/assets/the-standards/cft_non-lunch_guidance.pdf Accessed October 2014.
31. Department of Health: *Dietary Reference Values for Food Energy and Nutrients for the United Kingdom*. London: HMSO; 1991.
32. *Communities and Local Government Indices of Deprivation 2007*, <http://webarchive.nationalarchives.gov.uk/+http://www.communities.gov.uk/communities/neighbourhoodrenewal/deprivation/deprivation07/> Accessed June 2011.
33. Craig P, Cooper C, Gunnell D, Haw S, Lawson K, Macintyre S, Ogilvie D, Petticrew M, Reeves B, Sutton M, Thompson S: **Using natural experiments to evaluate population health interventions: new Medical Research Council guidance.** *J Epidemiol Community Health* 2012, doi:10.1136/jech-2011-200375.
34. Pockett RD, Adlard N, Carroll S, Rajoriya F: **Paediatric hospital admissions for rotavirus gastroenteritis and infectious gastroenteritis of all causes in England: an analysis of correlation with deprivation.** *Curr Med Res Opin* 2011, **27**:777–784.
35. Doyle W, Jenkins S, Crawford MA, Puvandendran K: **Nutritional survey of schoolchildren in an inner city area.** *Arch Dis Child* 1994, **70**:376–381.
36. James PWT, Nelson M, Ralph A, Leather S: **Socioeconomic determinants of health: the contribution of nutrition to inequalities in health.** *BMJ* 1997, **314**:1545.
37. Sausenthaler S, Kompauer I, Mielck A, Borte M, Herbath O, Schaaf B, von Berg A, Heinrich J: **Impact of parental education and income inequality on children's food intake.** *Public Health Nutr* 2007, **10**:24–33.
38. Dubois L, Farmer A, Girard M, Burnier D, Porcherie M: **Demographic and socio-economic factors related to food intake and adherence to nutritional recommendations in a cohort of pre-school children.** *Public Health Nutr* 2011, **14**:1096–1104.
39. Adamson AJ, Rugg-Gunn AJ, Butler TJ, Appleton DR, Hackett AF: **Nutritional intake, height and weight of 11-12-year-old Northumbrian children in 1990 compared with information obtained in 1980.** *Br J Nutr* 1992, **68**:543–563.
40. Krolner R, Rasmussen M, Brug J, Klepp K, Wind M, Due P: **Determinants of fruit and vegetable consumption among children and adolescents: a review of the literature. Part II: qualitative studies.** *Int J Behav Nutr Phys Act* 2011, **8**. doi:10.1186/1479-5868.
41. Whitham G: *Child Poverty in 2012: It Shouldn't Happen Here*. London: Save the Children; 2012.
42. McNeill G, Masson LF, Craig LCA, Macdiarmid JJ, Holmes BA, Nelson M, Sheehy C: **Sugar and fat intake among children in Scotland: what is needed to reach the dietary targets?** *Public Health Nutr* 2010, **13**:1286–1294.

43. Stevens L, Nelson M: **The contribution of school meals and packed lunch to food consumption and nutrient intakes in UK primary school children from a low income population.** *J Hum Nutr Diet* 2011, **24**:223–232.
44. Mendoza JA, Watson K, Weber Cullen K: **Change in dietary energy density after implementation of the Texas School Nutrition Policy.** *J Am Diet Assoc* 2010, **110**:434–440.
45. Rees GA, Richards CJ, Gregory J: **Food and nutrient intakes of primary school children: a comparison of school meals and packed lunches.** *J Hum Nutr Diet* 2008, **21**:420–427.
46. Pearce J, Harper C, Haroun D, Wood L, Nelson M: **Key differences between school lunches and packed lunches in primary schools in England in 2009.** *Public Health Nutr* 2011, **14**:1507–1510.
47. White M, Adams J, Heywood P: **How And Why Do Interventions That Increase Health Overall Widen Inequalities Within Populations?** In *Health, Inequality and Society*. Edited by Babones S. Bristol: Policy Press; 2009.
48. Lorenc T, Petticrew M, Welch V, Tugwell P: **What types of interventions generate inequalities? Evidence from systematic reviews.** *J Epidemiol Community Health* 2012. doi:10.1135/jech-2012-201257.
49. Moore L, de Silva-Sangigorski A, Moore SN: **A socio-ecological perspective on behavioural interventions to influence food choice in schools: alternative, complementary or synergistic?** *Public Health Nutr* 2013, **16**:1000–1005.
50. *The School Food Plan.* www.schoolfoodplan.com Accessed December 2013.
51. Watt RG, Dykes J, Sheiham A: **Socio-economic determinants of selected dietary indicators in British pre-school children.** *Public Health Nutr* 2001, **4**:1229–1233.
52. Romon M, Lommez A, Tafflet M, Basdevent A, Oppert JM, Bresson JL, Ducimetiere P, Charles MA, Borys JM: **Downward trends in the prevalence of childhood overweight in the setting of 12-year school- and community-based programmes.** *Public Health Nutr* 2009, **12**:1735–1742.

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Chapter 6 Discussion

Chapter overview:

The four first author papers included in this doctoral statement each gave the key findings, relationship to other studies and key strengths and limitations. A brief summary only of the key findings, relationship to other studies and strengths of these papers are given in this chapter. In an attempt to consider issues that extend beyond Papers II-IV it was considered appropriate to take a broader approach to the limitations of this body of work. Therefore limitations will be discussed with a focus on study design, evaluation: the 'ideal' and 'reality', and the outcomes measured. The key policy implications and areas for future research are considered, and finally some concluding remarks

6.1 Summary of key findings

Dietary

The findings in Papers II and III show that the implementation of legislation to school lunch in England has been associated with positive changes to children's diets at lunchtime and in their total diet; this was more apparent in the 4-7y olds. At lunchtime, children who ate a school lunch post-policy implementation derived a lower per cent of energy from fat, saturated fat and consumed lower absolute amounts of sodium (mg). In the 4-7y olds, mean intakes of calcium (mg), vitamin C (mg) and iron (mg) increased (Paper II). In 11-12y olds, non-starch polysaccharides (g) and iron (mg) decreased (Paper III). A child's lunch type was associated with change in the total dietary intake in 4-7y olds. Post-policy implementation children eating a school lunch had a healthier total diet compared with children eating a home-packed lunch (Paper II). In 11-12y olds, there was limited evidence found that lunch type was associated with change in total diet (Paper III). There was some evidence that post-policy implementation, lunch type and level of deprivation were associated with differences in per cent

energy from non-milk extrinsic sugars and vitamin C (mg) intake in the total diet of 4-7y olds (Paper IV). For children consuming a school lunch per cent energy from NMES reduced to similar levels for all the deprivation groups thereby narrowing inequalities, whereas for children consuming a home-packed lunch, the decrease was less marked in the least deprived group. For children consuming a school lunch children's vitamin C (mg) intake was now similar, leading to a narrowing of socio-economic inequalities. Whereas, for children consuming a home-packed lunch there was a widening of socio-economic inequalities; with children from the least deprived families now having a substantially higher intake (Paper IV). There was no evidence of a lunch type and level of deprivation effect found in 11-12y olds (Paper III). Post-policy implementation, school lunch take-up decreased in both age groups (Paper III and IV).

Methodological

For all children eligible, completion was more likely if passive consent was used. When only children who gave consent were considered, completion was less likely when passive rather than active consent was used. There was no evidence found that the odds ratio for the method of consent varied by level of deprivation. There was no evidence that the quality of dietary data, as measured by an assessment of under-reporting, differed by method of consent (Paper I).

6.2 Relationship to other studies

The findings reported in Papers II and III on the impact of implementing nutritional standards on children's mean dietary intake at lunchtime are similar to other studies.^{78, 79} For example, children's per cent energy from fat and saturated fat decreased. The finding that the impact on children's mean micronutrient intakes is inconsistent is also similar to other studies^{84, 85, 92} cited in the narrative literature review. For example, in the 4-7y olds (Paper II) children's mean calcium, vitamin C and iron intakes increased (statistically significant for all). In the 11-12y olds (Paper III) mean iron intakes decreased (statistically significant) and there was no evidence of a statistically significant difference in mean calcium and vitamin C intakes. Suggested reasons for the differences observed in the 4-7y and 11-y olds were discussed in section 5.1. A

number of reasons potentially explain the differences across studies (those cited in the narrative literature review and in Papers II and III) in children's micronutrient intakes. For example, the dietary data collection methods and duration of studies differed. The ages of children were also different. Also, there is variation in what individual children choose to eat from the foods available. The food-based standards specified which foods could, and perhaps more importantly, which foods could not be served. For example, the reduction in the frequency of serving of deep fried foods such as chips. The restrictions to what foods can be served may have a greater impact on children's dietary intake as opposed to increasing availability of fruit and vegetables. This is supported by the nutrient findings presented in Paper II & III and those cited in the narrative literature review: per cent energy from fat and saturated fat decreased, whereas change in children's micronutrient intakes is inconsistent.

The findings on children's total diet in Papers II-IV are unique. No previous study has reported the impact of implementing nutritional standards (pre and post-policy implementation) to school lunch in England on children's total diet. In addition, only one study in Canada⁹⁷ cited in the narrative literature review has examined the impact of a change in school food policy on children's total dietary intake. No prior study has examined the impact of a change in school food policy on children's dietary intake across the socio-economic spectrum using individual level socio-demographic information. The findings in Paper I are unique; the author is not aware of any previous papers reporting similar outcomes in dietary surveys. Previous research on the method of consent and adolescents has focused on tobacco and alcohol.^{115 116, 117} These studies also highlight the ethical questions surrounding the use of active and passive consent. However, they also note a number of negative implications with the use of active consent: adolescents may be put off from finding treatment or participating, the sample may be biased to include adolescents who have fewer problem behaviours and more parental involvement.¹¹⁵ Unger *et al*, 2004¹¹⁷ also noted boys, students with poorer grades, and students involved in behaviours, for example smoking, were more likely to have parents/guardians who did not respond to the use of active consent. By excluding these students this potentially leads to an underestimation of smoking prevalence which impacts on the conclusions of school-based program evaluations.¹¹⁷ Henry *et al*, 2002¹¹⁶

further support the view that using active consent impacts on the representativeness of the sample and generalisability of findings. They found the sample using active parental consent represented students that were less at risk from problem behaviours than would have been obtained had passive consent been used.¹¹⁶ There is no question that the use of active and passive consent poses various ethical questions for researchers. More research is required on the effects of the different consent procedures.¹¹⁷ Furthermore, researchers have to 'weigh up' the need to obtain a representative sample against the need to protect children and adolescents.¹¹⁸

6.3 Strengths and limitations

6.3.1 Strengths

The key strengths of the body of work reported in Papers II-IV are that they address some of the methodological limitations noted in previous work cited in Chapter 3. For example, more than one day of dietary data was collected. In children aged 4-7y dietary data were collected for a period of four days. This included three week days and one weekend day. In the 11-12y olds a 2 X three-day food diary was used; this also covered a range of week and weekend days. Therefore, this takes into account the issue of day to day variation in children's dietary intake. Furthermore, identical dietary data collection methods were employed both pre and post-policy implementation. Considering the effect of SES (Papers III & IV), individual child level socio-economic demographic data were used in the analysis as opposed to using school level SES relied upon in the majority of previous work.

6.3.2 Limitations

Papers I-IV each includes a discussion of the limitations of the studies. While writing Papers II-IV and conducting the narrative literature review, it was apparent a number of limitations with research evaluating the impact of nutritional standards in England exist; for example, the study designs and outcomes measured. These limitations apply beyond Papers II-IV. In an attempt to consider the key issues a broader approach to the limitations of this body of work has been taken. Three key aspects are discussed below: study designs, evaluation of the 'ideal' and the 'reality', and the outcomes measured.

6.3.2.1 Study design

To address childhood obesity, and as part of this children's diets, there has been increased pressure for governmental support and policy level interventions.^{15, 36, 119, 120} A recent systematic review by Driessen *et al*, 2014¹²¹ supports the view that national level policy changes to the school food environment can have a positive impact on what children eat.¹²¹ A prior systematic review of interventions for preventing childhood obesity also noted that improvements in the nutritional quality of school food is a positive policy strategy.¹²² However, this review by Waters *et al*, 2011¹²² also acknowledged that improvements are needed in study designs.

A limitation across research that evaluates the impact of the nutritional standards in England on children's dietary intake is the study design. Cross-sectional studies are the most frequently employed as noted in Chapter 3. The study design used in Papers II-IV is no exception; a repeated cross-sectional survey was employed in all papers. As noted in Papers II-IV, this limits the extent to which changes in children's dietary intake can be attributed to the implementation of nutritional standards.^{39, 47, 48} However, a major limitation that precluded the use of other study designs in the context of the body of work reported here is that there was national implementation of the nutritional standards in primary and secondary schools in England.^{39, 47, 48} With national implementation and no strategy for evaluation of the potential impact on children's diets,⁴⁶ this has limited the study designs that can be employed. Waters *et al*, 2011¹²² also identified other issues related to evaluation that need to be addressed: the process of implementation, the equitable impact and the evaluation of longer term outcomes.¹²²

Active and passive consent

The consent method used in research poses many ethical questions. Whether active 'opt-in' or passive 'opt-out' consent is used there are a number of issues for researchers to consider. As noted in Paper I a key aspect is that no one should be recruited without providing informed consent. When children are involved this is further complicated as parental/guardian consent is required.¹²³ In this thesis two different methods of consent were used in the published papers on children aged 4-7y and 11-12years dietary intake (papers II, III and

IV). Active consent was used in the 4-7y olds and passive consent was used in the 11-12y olds. The method of consent was changed in the 11-12y olds due to a low response rate in the 2007-08 survey and in response to preparatory discussions with head teachers who suggested the consent method should be changed from active to passive consent. This decision to change the recruitment procedure was not taken lightly; permission was granted by the Newcastle University Ethics committee. Documentation provided for ethical review included signed forms by head teachers and school governors to support this request.

There are a number of limitations in using active consent applicable to both age groups. The literature on active consent highlights that where letters are sent from schools (a method employed in this thesis) letters are less likely to be returned from children in more deprived families,¹²⁴ parental apathy also reduces consent rates^{124, 125} Other limitations more relevant for the 11-12y olds have been mentioned in section 6.2. Considering these limitations it is reasonable to suggest the method of consent may have impacted on the representativeness of the sample and thus generalisability of the findings. This is perhaps more pertinent in the 4-7y olds where active consent was used. Therefore, it is possible that a higher proportion of those who consented were from less deprived families and so the findings are less generalisable. In the 4-7y olds, to address whether there was a difference in the sample who consented and those who did not warrants further analysis. However, for this study, while it would be possible to examine this further in the 2008-09 data it is not possible to compare this in the 2003-04 data. This is a question for future research. It is important to note that between the two surveys there was no statistically significant difference in the mean IMD for those parents who consented to participate. Furthermore, we found that those in the more deprived families had lower mean intakes of key micronutrients. So while the sample may have been potentially biased towards less deprived families the key public health message from these findings does not change: public health strategies to address children's diets are required, perhaps even more importantly, in those from more deprived families. Had passive consent been used there is potential that the IMD effect would have been even more evident. In contrast, in the 11-12y olds passive consent was used in 2009-10 but not in the 2007-08 data

collection period. Analysis for Paper I was undertaken post dietary analysis (Paper IV) and provides some evidence that by using passive consent this provided a more representative sample and thus the findings are more generalisable. The aim of Paper I was to examine the effect of the different methods of consent and also the effect on the dietary data quality obtained. If active consent had been used it would be reasonable to suggest a much smaller sample would have participated and both the representativeness and generalisability of the findings would have been affected.

6.3.2.2 Evaluation ‘the ideal’ and the ‘reality’

A basic concept to evaluation is to identify whether an intervention is effective or not.^{126, 127} An intervention is defined as ‘*a set of actions with a coherent objective to bring about change or produce identifiable outcomes*’;¹²⁸ this includes policy. However, the process to establish this is not as easy. A number of aspects are noted as to what constitutes an ‘ideal’ evaluation in Table 15. This list is not exhaustive. Rather, it gives a contrast between criteria that are considered ‘ideal’ and some of the constraints in ‘reality’. An ‘ideal evaluation’ would include: a theoretical basis,^{129, 130} appropriate timing (i.e. not too soon post-implementation),^{131, 132} a mixed methods approach,¹³³ robust evaluation designs,^{127, 134} consideration of the potential wider impacts and pre-defined outcomes with suitable analysis^{135, 136} (see Table 15). In reality, the ‘ideal’ evaluation is limited by a number of factors. For example, public health interventions often lack theory,¹²⁷ interventions are often implemented before baseline data can be collected¹³⁷ and there is a disparity and often tension between what policymakers want to know and the type of evidence available^{136, 138} (see Table 15). This disparity alludes to the fact different agendas operate in policy making: researchers focus on evidence, for policy makers there is the consideration of both evidence and political factors.¹³⁹

Table 15 Evaluation: the 'ideal' and the 'reality'

Ideal	Reality
Theoretical basis	
Public health interventions based on theory can be more effective (NICE, 2007 ¹⁴⁰)	Complex public health interventions often lack theories (Moore <i>et al</i> , 2014 ¹²⁷)
Interventions to promote healthy eating need a theoretical basis (Atkins <i>et al</i> , 2013 ¹²⁹)	Policies to improve public health are often complex. Theories to support development and implementation are often inadequate (Ogilvie <i>et al</i> , 2011 ¹⁴¹)
Theory should be used to provide evidence that the intervention has the desired impact (Campbell <i>et al</i> , 2000 ¹³⁰)	
The MRC new guidance emphasise the importance of developing a theoretical understanding of the intervention (Craig <i>et al</i> , 2008 ¹²⁶)	Disparity can occur between the concern for a theory and what policy-makers want to know (Ogilvie <i>et al</i> , 2011 ¹⁴¹)
Robust evaluation designs	
Need for randomised control trials (RCT's) (Petticrew <i>et al</i> , 2012 ¹³⁴)	RCT's not always appropriate or possible (Achana <i>et al</i> , 2014 ¹³⁶),
	A systematic review found key aspects of using research in policy making are, for example, timeliness and clear recommendations. Research based on an RCT only reported in 3/24 studies (Innvaer <i>et al</i> , 2002 ¹³⁸)
Timing of evaluations	
Evaluations undertaken too soon after implementation may explain why interventions do not demonstrate an impact (Nutbeam, 1998 ¹³¹ ; Hawe <i>et al</i> , 2004 ¹³² and Ogilvie <i>et al</i> , 2011 ¹⁴¹)	Policies are often implemented without an opportunity to collect baseline data (House of Commons, 2009 ¹³⁷)
Mixed method designs	
Use of quantitative and qualitative research (Taylor <i>et al</i> , 2010 ¹³³)	
Need for improved analysis and evaluation methods (Smith <i>et al</i> , 2010 ¹³⁵)	
Need for process evaluations to understand how complex interventions are delivered and received (Moore <i>et al</i> , 2014); ¹²⁷ how they work (or do not work) and if the impact is equitable (Craig <i>et al</i> , 2008 ¹²⁶)	

Table 15 Evaluation: the 'ideal and the 'reality' continued	
Ideal	Reality
<i>Consideration of the wider impacts of the intervention</i>	
Consider the wider impacts on community, society and cost-effectiveness (NICE, 2007 ¹⁴⁰)	Evaluations focus on a few individual health outcomes (Smith <i>et al</i> , 2010 ¹³⁵)
<i>Identified outcomes and appropriate analysis</i>	
Smith <i>et al</i> , 2012 ¹³⁵ argue that 'individual level' analysis for macro-level interventions limits the evaluation	Achana <i>et al</i> , (2014 ¹³⁶): public health interventions are complex, consider various factors and often outcomes are not clear.

Table 15 highlights the external constraints that may impede the ability to fulfil an 'ideal' evaluation. The MRC framework 2008¹²⁶ was developed to provide a structure to guide the development and evaluation processes (Figure 9).

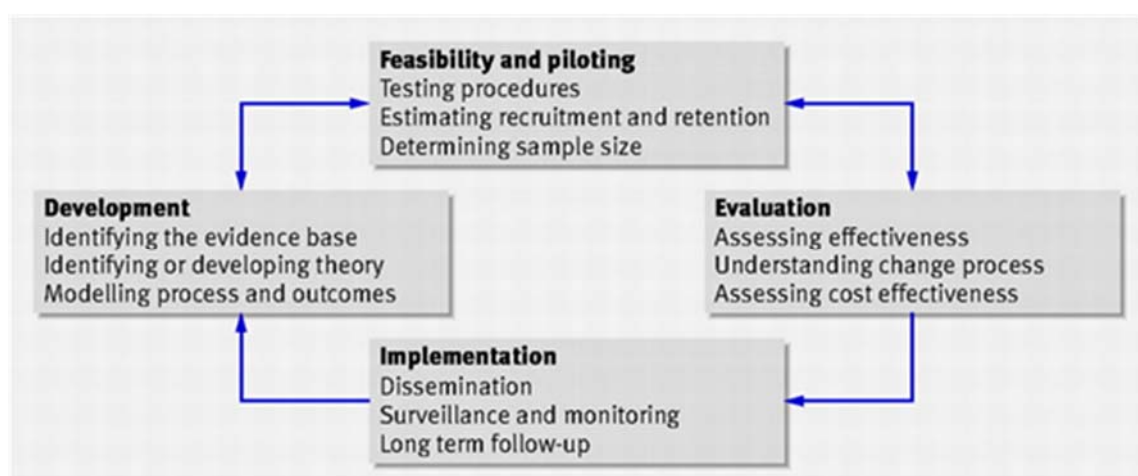


Figure 9 The MRC framework 2008: Key elements of the development and evaluation process

However, the processes in the MRC framework 2008¹²⁶ such as theory development and piloting were not considered prior to full implementation of the food and nutrient-based standards to school lunch in England. Some of the challenges specifically related to evaluating school food policies and potential solutions are discussed next.

Challenges and potential solutions for evaluating school food policies

External constraints limited factors in the evaluation of this policy change to school lunch and the impact on children's diets. Section 6.3.2.1 discussed limitations with the study designs in the evaluation process.

There are a number of difficulties with evaluating the school food policy. For example, there is the potential that multiple outcomes could be evaluated, considering the study designs used there is difficulty in attributing causal inferences and there is potential for both positive and negative outcomes. Other difficulties include variation in school compliance and the timing of the evaluation. The importance of timing of evaluations was highlighted in the literature review by Martin *et al*, 2010.⁷⁷ They noted in their study that schools may not have been fully compliant with the new recommendations as the study was undertaken soon after implementation; this potentially may have had an impact on findings.⁷⁷ The issue of school compliance is not covered in Table 15 but is of relevance to evaluations of school food policies. School compliance with policies need to be considered in evaluations and should be reported. A number of studies^{78, 79, 85} cited in the narrative literature review and Papers II-IV have considered children's mean nutrient intake from school lunches against the food and nutrient-based standards. However, the comparisons are limited as they do not cover the three-week menu cycle that the standards apply to.

One approach to address some of the constraints noted in Table 15 and discussed above is the use of a natural experiment design. This was the study design used and reported in Paper II. The use of a natural experiment is valuable for evaluating interventions such as the school food policy. In certain situations, study designs such as RCTs are inappropriate or impossible to use due to universal implementation of an intervention.¹⁴² However, the use of natural experiments should not replace more robust evaluations when these are possible.¹⁴²

Process evaluations

A further aspect highlighted by Waters *et al*, 2011¹²² was that evaluations need to consider the process of implementation. The implementation of the nutritional standards to school lunch was a 'top' down approach.¹³⁹ On reflection

stakeholders such as catering staff, lunchtime supervisors, local county councils, parents, head teachers and children were not considered in the development and implementation process. This omission to involve children in changes to school food has been a re-occurring issue in the history of school meals.^{56, 113}

To understand the complexity of health interventions there is an increasing awareness that process evaluations are needed.¹²⁷ Complex health interventions can include, for example, more than one outcomes and individuals potentially affected by the intervention.¹²⁶ School food policies are complex health interventions; they comprise a number of aspects which affect more than one outcome.

Process evaluations are required to explore the acceptability and context in which the intervention is delivered.^{126, 127} This potentially allows researchers to understand the strengths and weakness of the intervention^{126, 127} and areas which need to be addressed. The implementation of the food and nutrient-based standards required a change in practice among the numerous staff involved in the provision of school meals. Moore *et al*, 2014¹²⁷ highlight that behavioural changes are required by those implementing the policy and that personal skills and attitudes may be influential.^{143,144} These aspects potentially impact on the delivery of the intervention, in this case the school food policy. For example, a lack of compliance by schools and staff with the food and nutrient-based standards impacts on children's dietary intake. Understanding further the issues surrounding a lack of compliance is important to provide supportive measures for those implementing the policy. These are areas that cannot be elucidated by the quantitative approach taken in Papers II-IV.

Future evaluations of school food policies would benefit from the use of mixed methods approaches. These would enable more effective understanding of the impact of school food policies using the combined strengths from quantitative and qualitative analysis. For example, quantitative analysis enables identification of the impact on dietary related outcomes; qualitative analysis would assist in interpretation of findings and identification of practical areas for improvement.

Evaluation: school food policies

The importance of school food and school food policies has been recognised nationally and internationally.⁶⁵ A recent report by Bonsmann *et al*, 2014¹⁴⁵ mapped national school food policies across the EU, plus Norway and Switzerland. They found that while all countries ($n=34$) had a school food policy, half were voluntary. The most common aims of school food policies were to: improve child nutrition (97%), provide education on healthy diet and lifestyle habits (94%), and reduce/prevent childhood obesity (88%). Tackling health inequalities was an objective in about half.¹⁴⁵ The report also noted that not all countries considered evaluation. In the countries that did the top four outcomes evaluated were: food provision (56%), take-up of school meals (35%), nutrition of children (29%) and food consumption (24%).¹⁴⁵ Although the most common aim was to improve child nutrition (97%), children's nutrition and food consumption are evaluation outcomes in only approximately one quarter. This report and The EU Action Plan on Childhood Obesity 2014-2020 highlight the need for a greater focus on evaluating interventions.^{145, 146}

In January 2012, I attended an international workshop in London on developing the evidence base for policy relating to school food. This was a joint WHO-Europe and School Food Trust event. A number of key aspects pertaining to school food policies relevant to national and international contexts were discussed. Two of the main themes and ideas/discussions are presented in Table 16. The importance of the availability of baseline data was considered as well as potential outcomes that evaluations should consider. A further issue discussed was the variation between countries in what a school food policy entails; this was also noted in Chapter 3. This variation in school food policies means to date there is no internationally accepted framework for evaluating school food policies¹⁴⁷ Although Nelson *et al*, 2012¹⁴⁸ suggest universal guidance on school food policies is inappropriate, Bundy *et al*, 2013¹⁴⁹ highlight that engagement between policymakers across countries would be useful.

This section demonstrates that evaluations of school food policies are faced with numerous challenges. Additionally, the report by Bonsmann *et al*, 2014¹⁴⁵ highlights the variation in outcomes measured to evaluate the impact of school food policies. For example, only a quarter consider the impact on children's food

consumption. Papers II-IV used baseline data collected pre and post-policy implementation and considered some of the wider impacts; for example, children's total diet and the impact across the socio-economic spectrum. These findings can add to the evidence base on school food policies and the impact on children's diets. However, there are also limitations with the outcomes measured. The body of work cited in the narrative literature review and in Papers II-IV have focused on quantitative outcomes.

Table 16 A few of key ideas for developing the evidence base for policy relating to school food (WHO-Europe and School Food Trust)

Themes	Ideas/Discussions
Policy, guidelines and standards	<p>Need for baseline measurements; quantitative & qualitative methods</p> <hr/> <p>Evaluations should consider:</p> <ul style="list-style-type: none"> <li>➤ school lunch take-up <li>➤ compliance <li>➤ what children eat in their school and home-packed lunches, <li>➤ impact on total diet <li>➤ educational aspects (attendance, attainment) health (growth, obesity) <li>➤ economic (local food production, viability of school catering services)
Wider evidence base	Understand the impact according to socio-economic factors

Nelson *et al*, 2012¹⁴⁸

6.3.2.3 Outcomes

The outcomes evaluated in Papers II-IV and the body of work cited in the narrative literature review consider only the short term impacts of a school food policy on children's dietary intake. In addition, the evaluation in Papers II-IV focused on quantitative outcomes as did the body of work cited in Chapter 3.

The specific research questions in Papers II-IV were to examine the impact of implementing school food standards to school lunch in England on children's dietary intake at lunchtime and in total diet. The evaluation was quantitative and

focused on policy change at the macro-level. As discussed in section 2.3 a number of factors influence what children eat at the macro, physical, social and individual level.³⁸ Therefore, while the evaluations in Papers II-IV did not directly consider other levels it is important to acknowledge these. Table 17 provides a list of some of those identified in the literature, for example, lunchtime supervisors¹⁵⁰ and peer influence.¹¹⁴ Also, included are physical and environmental factors that have an influence, for example, the dining room environment.¹⁵¹ Using the basis of the socio-ecological framework,³⁸ a pictorial image of these factors is given in Figure 10. This shows the numerous factors that potentially influence children's dietary intake with specific reference to school lunch. Moore *et al*, 2011¹⁵¹ argue that the impact of macro-level interventions are potentially limited if other factors are not considered. Papers II-IV reported that implementation of the school food policy in England at the macro-level has been associated with positive change in children's dietary intake both at school and in total diet. However, in the 11-12y olds the impact was more limited. This may be because other factors (e.g. eating with friends) are equally influential in this age group. Therefore, evaluations that combine quantitative and qualitative methods would contribute to the evidence base on the impact of school food policies.

Table 17 Potential factors influencing what children consume at lunchtime

Level	Potential factors of influence
Macro	Food and nutrient-based standards ⁶⁴ Restrictions on availability: i.e. no soft drinks ⁶⁴ Increased availability of fruit & vegetables ⁶⁴ Compliance with standards ⁶⁴ Catering staff, service & menu planning ^{152, 153} Promotion of menus/whole school approach ¹⁵² Lunchtime supervisors; pressure, encouragement, rewards ^{150, 151} Engagement with parents & pupils re menus ¹⁵² Dining ambience, seating ^{151, 154} Food presentation and position on counters ¹⁵² Marketing of healthy options ¹⁵² Cost of foods: cheaper fruit & vegetables ¹⁵² Meal deals ¹⁵² Able to eat with friends, peer influence ^{114, 155} Time available, queues ¹⁵⁴ Attitudes ³⁸ Tastes, Food preferences ^{38, 155} Knowledge ³⁸
Individual	Age, Gender ³⁸

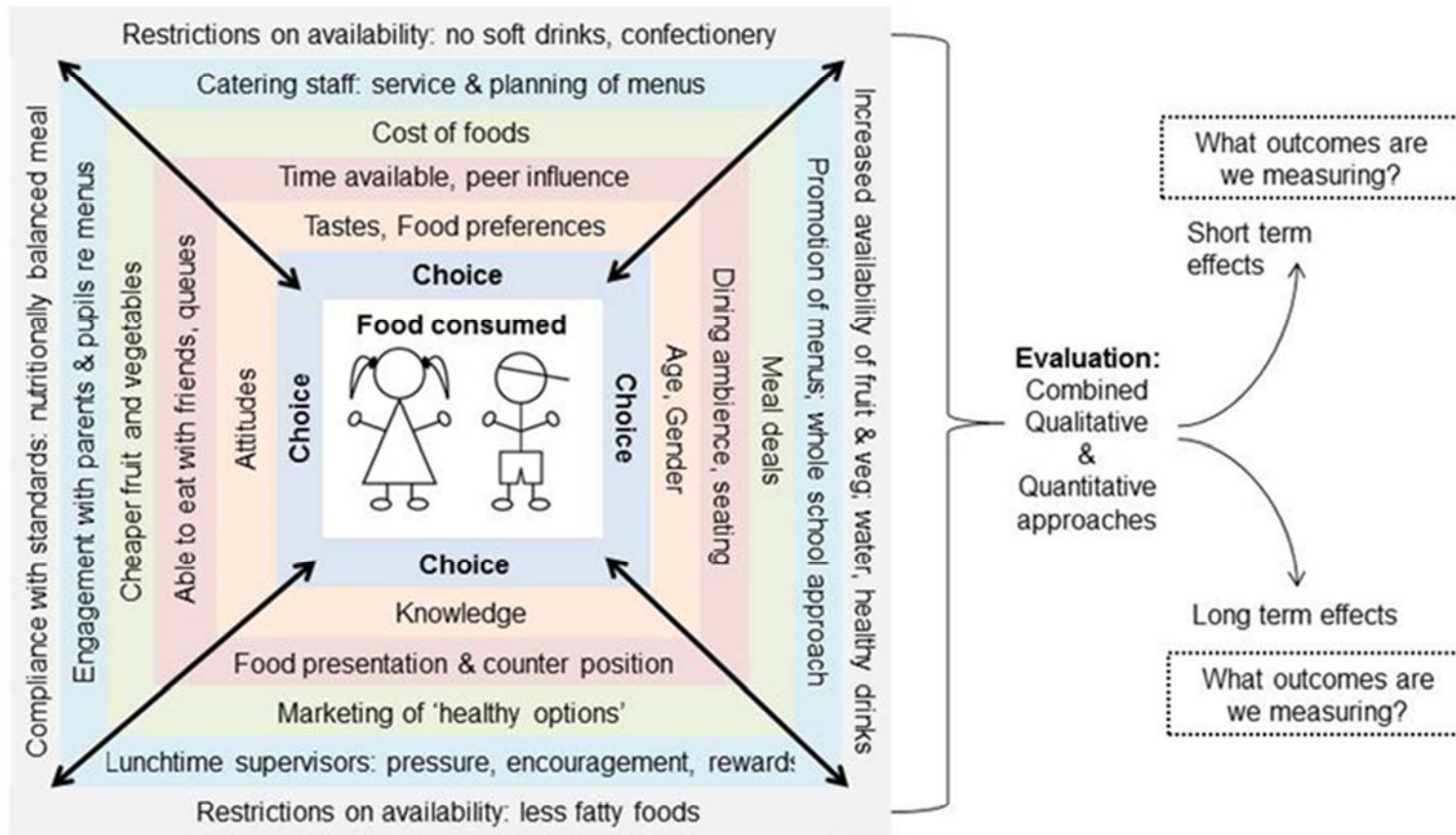


Figure 10 The multiple factors affecting what children eat in their school lunch and factors for future evaluations to consider (an adaptation of the socio-ecological framework)

6.4 Strategies for improving children's diets

Section 2.3 highlighted that many factors influence children's diets; section 6.3.2.3 focused on those relevant to the school environment. Two age groups were included in this thesis; strategies to improve diets of children may require a different focus for different age groups. While policy interventions to school food are applicable for all children different approaches to implement policy and to address other aspects of children's diets are likely to be needed. This section makes suggestions for approaches which are applicable to both age groups and makes specific suggestions that may be more appropriate to younger children (4-7y olds) and then older children (11-12y olds).

Improving children's diets at school requires addressing both the food available from which children are able to choose and additional factors, such as, individual, social and physical environments³⁸ as noted in section 2.3. An aspect that other research has focused on is the school dining hall. Moore *et al*, 2010¹⁵³ noted that children's eating experiences are influenced by both physical and social aspects in the school dining hall. Key issues which impact on children's eating experiences are space and time for eating. For example, it has been found that in some schools the arrangement of seating is for convenience and children are pressured to eat their lunch quickly.^{153, 156} There are often different seating areas for children eating school and home-packed lunches. It has been noted that children who eat home-packed lunches receive less supervision and also have more time to socialise with friends.¹⁵³ These are issues relevant to both 4-7 and 11-12y olds. There is a need across all age groups to make dining halls more conducive to have a positive impact on children's eating at lunch time. The school food plan has noted a number of strategies that schools have reported as practical tips to improve the dining experience and make lunchtimes a more positive social experience.¹⁵⁷ A few examples are: the use of round tables to encourage more interaction, the use of plates and bowls rather than plastic compartmented trays, encouraging children to try new foods and teachers eating with children. Other solutions have included integrating the school lunch into the curriculum where small groups of children sit with teaching assistants and talk about the food, and are served their food and encouraged to use a knife and fork.¹⁵⁷ Interestingly, the majority of reported solutions are focused on primary aged children, with less of a focus

on what works in secondary schools. One strategy noted in the older children is the use of allotments and children being involved in the growing of foods. Whilst these are reported as having had a positive impact there is no formal evaluation of these approaches or evidence that these are replicable across schools.

Other suggestions that could be tried at lunch time to improve children's dietary intake in the younger children are practical solutions such as cutting up fruit and placing it on the table for children to eat. This is in contrast to what was observed frequently in the primary schools during this research where whole pieces of fruit are placed beside the cake/biscuit and children are expected to choose fruit over cake and then manage a whole piece of fruit. For 11-12y olds there is a more limited focus on this age group in the literature and in the School Food Plan; work is needed to engage with 11-12y olds to identify potential solutions to improve their diets at lunch time.

School food can achieve only so much. To achieve the radical improvement needed in children's diets there is also a need to focus outside of the school environment. Whilst policy interventions can potentially influence large numbers of children, parental influence also has a key role in the younger children.¹⁵⁵ It is reasonable in the younger children that strategies to improve children's diets need to involve and focus on parents. Parents have a role in developing children's eating habits by encouraging food preferences and tastes.¹⁵⁸ This requires parents to encourage children to eat healthy foods and availability of healthy foods in the home.^{155, 158} Strategies to support parents to encourage young children to eat healthy foods are potential approaches.

Older children (11-12y olds and above) have more personal control over what and where they eat and so other strategies are required. In this age group factors such as price and convenience are important.¹⁵⁹ Cost has been noted to have a greater influence than providing nutritional information such as the calorie and fat content of foods.¹⁵⁹ There is an increasing focus on using taxation as a strategy to improve diets. One strategy has been to tax sugar sweetened beverages. Waterlander *et al*, 2014¹⁶⁰ found using a RCT within a three-dimensional web-based supermarket that higher taxes were effective in reducing the purchases of sugar sweetened beverages. A limitation with this study is whether these findings would be replicated in a 'real life' supermarket

situation. Despite this, the use of soft drink taxation to promote healthy dietary changes is further supported in a review by Thow *et al*, 2014.¹⁶¹ There are also some areas for consideration with the use of this strategy. Darmon *et al*, 2014¹⁶² highlighted that food price policies, for example, reducing the cost of fruit and vegetables may improve the diet but may adversely increase dietary inequalities. They found reducing the cost of fruit and vegetables and taxing unhealthy foods improved some aspects of the nutritional quality of food choices for women in both low and middle income groups, however, women from the low income group benefitted the least.¹⁶² Comans *et al*, 2013¹⁶³ highlight that the area of food taxation is complex. They argue that as there is no clear definition of what constitutes ‘healthy’ or ‘unhealthy’ foods; applying tax to food is more difficult than applying taxation to alcohol or cigarettes.¹⁶³ What this highlights is varied impacts and opinions in the use of food taxation and that more evidence is required.

A further area where strategies are required is in relation to food marketing; this is relevant to children of both age groups.³⁸ There is a need for a shift in food advertising to include the promotion of healthier foods and to include other types of media such as social media the wider internet.³⁸ This implies there is a need for strategies to include engagement with media and the food industry concerning advertising, food taxation and the nutritional content of products. It is apparent a combination of strategies is required to improve children’s diets. There are also instances when age-specific interventions may be more appropriate.

6.5 What Papers II-IV add to the evidence base on school food

Papers II-IV add a number of unique and important aspects to the evidence base on school food policies. The findings in Papers II-IV address a number of issues that were identified as priorities in evaluating school food policies at the joint WHO-Europe and School Food Trust event in January 2012. For example, the use of baseline data, children’s consumption in school and home-packed lunches, the impact on total diet and the impact across the socio-economic spectrum.

Lunchtime

Limitations with previous research

Out of the eight studies cited in the literature review that examined what children consumed in their school lunch, only three studies used a pre and post-policy design. One was conducted in primary school aged children and two in middle/secondary aged children. No previous study identified in the literature review has compared the difference between what children eat in school and home-packed lunches using a pre and post-policy design. In addition, the majority of these studies have used only one day of dietary data (see table 10).

What my research adds

A strength of the findings presented in Papers II-IV is the analysis has included more than one day of dietary data collection. Therefore, children's dietary variation in week and weekend days has been considered. In addition, the findings in Papers II-IV add to the limited evidence available on the effect of a change in school food policy and what children eat in their school lunch in two age groups: 4-7y olds and 11-12y olds.

The findings at lunchtime in both 4-7y and 11-12y olds show improvements in mean intakes of some nutrients post-policy implementation. For children aged 11-12y there was evidence of a decrease in certain key micronutrients which was not observed in primary school children. This highlights the potential positive influence school food policies can have on children's intake at lunch time. It also highlights that for children aged 11-12y there is a need to understand other factors that potentially influence children's intakes at lunchtime as a decrease in some key micronutrients was reported.

Total diet

Limitations with previous research

Only one previous study in Canada has examined the effect of a change in school food policy on children's total diet in primary school aged children. The study used dietary data collected only on one day both before and after policy implementation. Therefore, there is very limited evidence of the wider impacts of school food policies on children's total dietary intake.

What my research adds

Papers II-IV add evidence on the impact of implementing a school food policy on children's dietary intake in 4-7y and 11-12y olds in England. This study used dietary data collected pre and post-policy implementation to included week and weekend days.

The findings provide some evidence that change in school food policies are also reflected in children's total diet. For example, in the 4-y olds post-policy implementation a child who ate a school lunch had a lower per cent energy from fat (compared to higher pre-policy). Children were also found to have higher mean intakes of some micronutrients. The findings in the 11-12y olds of an impact on their total diet were limited reinforcing that to address children's diets in this age group additional approaches are required.

In both age groups, children's per cent energy from saturated fat and NMES were above the DRVs as were the absolute amounts of sodium. For the 11-12y olds, mean iron intake was below the RNI. This highlights that despite a major policy change to school food in England, there is still a need to address children's diets in both primary and middle school aged children.

Impact across the socio-economic spectrum**Limitations with previous research**

A small number of studies have examined the effect of SES; this has been limited to school level analysis as opposed to individual level. In addition, no study identified in the literature review has examined the effect of a change in school food policy across the socio-economic groups by lunch type at lunch time or in children's total dietary intake.

What my research adds

The findings in Papers III and IV are unique. No previous study has examined the impact of a change in school food policy on children's dietary intake using individual level data. This research is the first to provide some evidence on the impact of implementing school food policies across the socio-economic spectrum on children's dietary intake at lunchtime and in their total diet.

In the total diet of 4-7y olds, year, lunch type and level of deprivation were found to influence children's mean per cent energy from NMES and vitamin C. For example, for children who consumed a school lunch, per cent energy from NMES reduced to similar levels for all the deprivation groups, thereby narrowing inequalities. While for children who consumed a home-packed lunch, the decrease was less marked in the least deprived group. The findings from this research indicate school lunch may have some influence on addressing children's dietary inequalities.

School lunch take-up

School lunch take-up decreased more in the 11-12y olds pre to post-policy implementation (81% to 36%) compared with the 4-7y olds (60% to 51%). The impact of changes to school lunch, however beneficial, have no effect on children who do not consume them. This highlights a need for strategies to address school lunch take-up particularly in the 11-12y olds. A large percentage of 11-12y olds in this study sample choose home-packed lunches. Therefore, approaches to improving home-packed lunches also need consideration.

To continue to develop the evidence base on the impact of school lunch on children's diets there is a need for more national and international collaboration to ensure more consistent, robust and thus comparable evaluations.

6.6 Implications for policy and further research

6.6.1 Key policy implication

In September 2013, the government announced that free school meals would be available for all children in reception, year 1 and year 2 in state-funded schools from September 2014.¹⁶⁴ This announcement followed a recommendation from the School Food Panel, an independent review of school food published in July 2013.¹⁶⁵ Members of this expert panel included school heads, cooks, city council members and academics. The recommendation was to some extent based on consideration of scientific evidence on home-packed lunches,⁸² school lunches^{39, 42, 84} and the free school meal pilot.¹⁶⁶

All statutory funded schools in England, including new Academies and free schools are expected to adhere to this under the Children and Families Act 2014.¹⁶⁷ The School Food Plan also devised new school food based standards and removed the nutrient-based standards. The rationale for the removal of nutrient-based standards was that they were somewhat complicated and perhaps impeded innovation by school cooks and chefs.¹⁶⁵ The new food-based standards have been approved and will become a legal requirement for schools from January 2015.

The recommendation of universal free school meal (UFSM) can potentially impact on large numbers of children's diets. It is regrettable that evaluating the impact of UFSM on children's dietary intake has not been included in how the success of the School Food Plan will be measured. Chapter 12 of the School Food Plan sets out how the government will measure the success in five points. The two of relevance are: monitoring school meals take-up and the nutritional quality of the food assessed by the number of schools meeting the new standards.¹⁶⁵ Possibly, of more relevance, would have been a focus on evaluating what children actually eat. With national implementation since September, 2014 there has also been a missed opportunity to collect baseline data and evaluate the impact pre to post-implementation. This reiterates the persistent gap between issues in obtaining 'ideal' evaluations and 'reality'. There is a need for a more concerted effort for public health professionals, academics and government not only to recognise evaluation as an integral component during the development periods of major policy changes, but to ensure that this happens.

In addition, the wisdom of removal of the nutrient-based standards is debateable, and requires monitoring and evaluation. In practice, nutrient-based standards are more complex to implement, however, research that has evaluated the impact of nutrient-based standards has found improvements in children's nutrient intakes,^{39, 48,78, 79} evidence of their effectiveness. Rather than the complete removal of nutrient-based standards, an alternative solution would have been to revise their complexity: the period could have been changed to cover a one-week menu cycle rather than three thus simplifying calculations required.

6.6.2 Future research

There are a number of areas for future research to consider in evaluating the impact of nutritional standards in England on children's diets. Further studies are needed to support the findings in Papers II-IV that examine the wider impacts on children's total diet and across the socio-economic spectrum. Closely related to this point is the need for studies to use pre and post-policy implementation designs to evaluate the impacts. Whether the use of a controlled before and after study can be employed needs considered.

With limited evidence of a lunch type effect in the 11-12y olds future research needs to involve and consider strategies on how to improve their diets.

Research to date has focused on short term outcomes. Future evaluations could consider how to evaluate longer term effects of school lunch. For example, are there any longer term benefits on children's dietary intake and habits? Does exposure to improved school food translate to food preferences and do these preferences track to adulthood?

With the implementation of UFSM for children in Key Stage 1 there is a need to evaluate the impact. Ideally pre-implementation data should have been collected to examine the impact on children's diets across the socio-economic spectrum. Although this opportunity has been missed, studies could consider methodological approaches to examine the potential 'wider' impacts of this policy change. For example, in the family diet; does economic savings from not having to pay for children's school/home-packed lunch impact on the family's diet at home?

There is some potential that routinely collected dietary data in the NDNS could be used to examine the impact of universal free school meals. This would enable trends to be noted in free school meal uptake and total diet. For example, using the NDNS data could enable a comparison of children receiving UFSM in the new rounds of NDNS data collection compared to pre-UFSM and whether there is an impact on total diet. The NDNS collects data that includes England, Wales, Scotland and N. Ireland. Currently, in England there is a legal requirement for the provision of universal free school meals for children in Key stage 1; this is not a legal requirement in Wales, Scotland and N. Ireland. This

factor would need to be considered in evaluations using the NDNS dietary data. However, there are limitations with this approach. One key limitation is the ability to assess more detailed dietary related outcomes of the impact of free school meals on children's total dietary intake. The NDNS collects information on time of intake but not by lunch type. Also, dietary intake is reported by parents; proxy reporting for the younger children having a school lunch is a further limitation considering the difficulties of self-report in this age group.

6.7 Concluding remarks

This doctoral statement started with an overview of child health and the shift in focus from under- to overnutrition. The history of school meals reflects the challenges in child health over the last 100 years. Initially, school meals were introduced to improve children's diets due to under-nutrition.⁴⁹ The current focus is on improving what children eat and developing 'healthier' eating habits to reduce childhood overweight and obesity.^{11, 12} A key focus has been on improving the nutritional quality of school lunch and there have been many improvements. In 2013, Gove (then Minister for Education) stated:

'.....making sure that there is a proper lunch to look forward to; and making sure that as well as having choice, children are eating food that is healthy. The school lunch or dinner- the central meal of the day for many children - needs to be of the highest possible quality' (Gove, 2013 p21)¹⁶⁵

Papers II-IV highlighted the implementation of school food and nutrient-based standards in England have been associated with positive changes in children's dietary intake at lunchtime. For example, children's per cent energy from fat and saturated fat reduced. These changes were reflected in the total diets of the 4-7y olds but evidence was more limited in 11-12y olds. There was some, though limited, evidence that school lunch may have an influence on addressing children's dietary inequalities.

A number of studies^{74, 78, 79} cited in the narrative literature review and Papers II & IV highlight school compliance with school food policies and children's food choices are important factors. In addition, whether a child chooses to consume a school or home-packed lunch is also key. The impact of changes to school lunch, however beneficial, have no effect on children who do not consume

them.⁴⁸ Thus, strategies to encourage school lunch take-up are needed. In 1952, Hall⁵² noted that adequate supervision, sufficient time to eat and the environment school lunches were consumed in were important factors; as noted in section 6.3.2.3 these remain relevant today. Improving school lunch continues to require a focus on both the nutritional quality, and also the social and physical environments in which these are consumed.¹⁵¹

Papers II-IV found that children's dietary intake of per cent energy from saturated fat and NMEs exceeded the recommendations (DRVs²¹) highlighting strategies to address this are needed, and perhaps this requires further legislation. Finding appropriate and effective solutions remains a persistent challenge for professionals working in child health and for policy makers. To identify appropriate solutions requires a concerted effort by public health professionals, funding bodies, academics, policy makers and government to recognise evaluation as an integral component to this. Evaluations of the impact of school food standards on children's dietary intake are complex as highlighted in section 6.3.2.2 and have been limited by a number of external constraints. To improve children's diets in all their complexity, future interventions also need to consider the social, environmental and behavioural contexts in which food choices are made or directed, both in and outside of the school environment.

References

1. WHO. (2003) *Diet, Nutrition and the Prevention of Chronic Disease: Report of a Joint WHO/FAO Expert Consultation*. Geneva:WHO
2. Foresight. (2007) *Tackling obesity:Future Choices-Project Report*.
3. Swinburn CD, Waters E, Edmunds L, Kelly SAM, Brown T and KJ Campbell. (2009) Interventions for preventing obesity in children (Review). *The Cochrane Library*.
4. WHO. <http://www.who.int/topics/diet/en/> Accessed 23rd October, 2014
5. Department of Health. (1989) *The Diets of British Schoolchildren. Sub-committee on Nutritional Surveillance. Committee on Medical Aspects of Food Policy*. London:Department of Health
6. Gregory J and Lowe S. (2000) *National Diet and Nutrition Survey: young people aged 4 to 18 years*. London:HMSO
7. Bates B, Lennox A and Swan G. (2010) *National Diet and Nutrition Survey-headline results from year 1 (2008-2009)*. London:Department of Health
8. Bates B, Lennox A, Prentice A, Bates C and Swan G. *National Diet and Nutrition Survey: Headline results from Years 1, 2 and 3 (combined) of the Rolling Programme (2008/9-2010/11)*.
<http://webarchive.nationalarchives.gov.uk/20130402145952/http://transparency.dh.gov.uk/2012/07/25/ndns-3-years-report/> Accessed 22nd January, 2013
9. Stamatakis E, Wardle J and Cole TJ. (2010) Childhood obesity and overweight prevalence trends in England: evidence for growing socioeconomic disparities. *International Journal of Obesity*. 34 p.41-47
10. Stamatakis E, Zaninotto P, Falashetti E, Mindell J and Head J. (2010) Time trends in childhood and adolescent obesity in England from 1995 to 2007 and projections of prevalence to 2015. *Journal of Epidemiology and Community Health*. 64 p.167-174
11. Department of Health. (2004) *Choosing Health: Making healthy choices easier*. London:Department of Health
12. Department of Health. (2005) *Choosing a better diet: A food and health action plan*. London:Department of Health
13. *The Education Act.The Education (Nutritional Standards and Requirements for School Food) (England) (Amendment) Regulations 2008*.
http://www.opsi.gov.uk/si/si2008/pdf/uksi_20081800_en.pdf Accessed 28th March, 2012
14. Blair M, Stewart-Brown S, Waterston T and Crowther R. (2003) *Child Public Health*. Oxford:University Press
15. Ebbeling CB, Pawlak DB and Ludwig DS. (2002) Childhood obesity: public health crisis, common sense cure. *Lancet*. 360 p.473-582
16. Lobstein T, Baur L and Uauy R. (2004) Obesity in children and young people: a crisis in public health. *Obesity reviews*. 5 (Suppl.1) p.4-85

17. Craigie AM, Lake AA, Kelly SA, Adamson AJ and Mathers JC. (2011) Tracking of obesity-related behaviours from childhood to adulthood: A systematic review. *Maturitas*. 70 p.266-284
18. Leslie WS, Comrie F, Lean MEJ and Hankey CR. (2012) Designing the eatwell week: the application of eatwell plate advice to weekly food intake. *Public Health Nutrition*. 16 (5), p.795-802
19. NHS choices. *The Eatwell Plate*.
www.nhs.uk/Livewell/Goodfood/pages/eatwell-plate.aspx Accessed 14th July, 2014
20. NHS Change4Life.
www.nhs.uk/change4life Accessed 14th July, 2014
21. Department of Health. (1991) *Dietary Reference Values for Food Energy and Nutrients for the United Kingdom*. London: HMSO
22. WHO. (2003) *Fruit and vegetable promotion initiative: A meeting report*. Geneva:WHO
23. Scientific Advisory Committee. (2011) *Dietary Reference Values for Energy*. London: The Stationery Office
24. WHO. *WHO opens public consultation on draft sugar guidelines*.
<http://www.who.int/mediacentre/news/notes/2014/consultation-sugar-guideline/en/>
Accessed 12th November, 2014
25. WHO. *Draft guidelines on free sugars released for public consultation 5 March 2014*.
www.vzhh.de/ernaehrung/338514/DraftWHO sugars guideline.pdf Accessed 12th November, 2014
26. GOV.UK.
www.sacn.gov.uk/pdfs/sacn_press_release_carbohydrates_and_health.pdf Accessed 14th July, 2014
27. Prynne CJ, Paul AA, Price GM, Day KC, Hilder WS and Wadsworth MEJ. (1999) Food and nutrient intake in a national sample of 4-year-old children in 1950: comparison with the 1990s. *Public Health Nutrition*. 2 (4), p.537-547
28. Bates B, Lennox A, Prentice A, Bates C, Page P, Nicholson S and Swan G. (2014) *National Diet and Nutrition Survey: results from years 1-4 (combined) of the Rolling Programme 2008/2009-2011/12*. London: Public Health England
29. The Marmot Review. (2010) *Fair Society, Healthy Lives*. London: The Marmot Review
30. Darmon N and Drewnowski A. (2008) Does social class predict diet quality? *American Journal of Clinical Nutrition*. 87 p.1107-1117
31. Cameron AJ, Ball K, Pearson N, Lioret S, Crawford DA, Campbell K, Hesketh K and McNaughton SA. (2012) Socioeconomic variation in diet and activity-related behaviours of Australian children and adolescents aged 2-16 years. *Pediatric Obesity*. 7 p.329-343
32. Romon M, Lommez A, Tafflet M, Basdevent A, Oppert JM, Bresson JL, Ducimetiere P, Charles MA and Borys JM. (2009) Downward trends in the prevalence

- of childhood overweight in the setting of 12-year school- and community-based programmes. *Public Health Nutrition*. 12 p.1735-1742
33. Rokholm B, Baker JL and Sorensen TIA. (2010) The levelling off of the obesity epidemic since the year 1999-a review of evidence and perspectives. *Obesity Reviews*. 11 p.835-846
34. Department of Health. (2011) *National Child Measurement Programme: England, 2010/11 school year*. London:Department of Health
35. Heitmann BL, Koplan J and Lissner L. (2009) Childhood obesity: successes and failures of preventive interventions. *Nutrition Reviews*. 67 (Suppl. 1) S89-S93
36. Gortmaker SL, Swinburn BA, Levy D, Carter R, Mabry PL, Finegood DT, Huang T, Marsh T and Moodie ML. (2011) Changing the future of obesity: science, policy and action. *Lancet*. 378 p.838-846
37. Borys JM, Le Bodo Y, Jebb SA, Seidell JC, Summerbell C, Richard D, De Henauw S, Moreno LA, Romon M, Visscher TLS, Raffin S, Swinburn B and the EEN Study Group. (2012) EPODE approach for childhood obesity prevention: methods, progress and international development. *Obesity reviews*. 13(4), p.299-315
38. Story M, Kaphingst KM, Robinson-O'Brien R and Glanz K. (2008) Creating Healthy Food and Eating Environments: Policy and Environmental Approaches. *The Annual Review of Public Health*. 29 p.253-272
39. Spence S, Delve J, Stamp E, Matthews JNS, White M and Adamson AJ. (2013) The Impact of Food and Nutrient-Based Standards on Primary School Children's Lunch and Total Dietary Intake: A Natural Experimental Evaluation of Government Policy in England. *PLoS One*. 8(10):e78298.doi:10.1371/journal.pone0078298
40. Jaime PC and Lock K. (2009) Do school based food and nutrition policies improve diet and reduce obesity? *Preventive Medicine*. 48 (1), p.45-53
41. van Cauwenberghe E, Maes L, Spittaels H, van Lenthe FJ, Brug J, Oppert JM and de Bourdeaudhuij I. (2010) Effectiveness of school-based interventions in Europe to promote healthy nutrition in children and adolescents: systematic review of published and 'grey' literature. *British Journal of Nutrition*. 103 p.781-797
42. Adamson AJ, White M, Stead M, Delve J, Stamp E, Matthews JNS, Eadie D and Spence S. (2011) *The process and impact of change in the school food policy on food and nutrient intake of children aged 4-7 and 11-12 years both in and out of school: a mixed methods approach*. http://phrc.lshtm.ac.uk/papers/PHRC_B5-07_Final_Report.pdf
43. HM Government. (2007) *PSA Delivery Agreement 12: Improve the health and wellbeing of children and young people*. London:The Stationery Office
44. HM Government. (2008) *Healthy Weight, Healthy Lives: A Cross-Government Strategy for England*. London:HMSO
http://webarchive.nationalarchives.gov.uk/20100407220245/http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/documents/digitalasset/dh_084024.pdf
45. Cabinet Office. (2008) *Food matters: towards a strategy for the 21st Century*. London:HMSO

46. Adamson AJ, Spence S, Reed L, Conway R, Palmer A, Stewart E, McBratney J, Carter L, Beattie S and Nelson M. (2013) School food standards in the UK: implementation and evaluation. *Public Health Nutrition*. 16 (6), p.968-981
47. Spence S, Matthews JNS, White M and Adamson AJ. (2014) A repeat cross-sectional study examining the equitable impact of nutritional standards for school lunches in England in 2008 on the diets of 4-7y olds across the socio-economic spectrum. *International Journal of Behavioral Nutrition and Physical Activity*. 11:128. doi:10.1186/s12966-014-0128-6
48. Spence S, Delve J, Stamp E, Matthews JNS, White M and Adamson AJ. (2014) Did School Food and Nutrient-Based Standards in England Impact on 11–12Y Olds Nutrient Intake at Lunchtime and in Total Diet? Repeat Cross-Sectional Study. *PLoS One*. 9(11):e112648. doi:10.1371/journal.pone0112648
49. Caroline Walker Trust. (1993) *Nutritional guidelines for school meals: report of an expert working group*.
50. *The Education (Provision of Meals) Act 1906*.
<http://www.legislation.gov.uk/ukpga/1906/57/section/2/enacted> Accessed 14th March, 2013
51. Webster C. (1985) Health, Welfare and Unemployment during the Depression. *Past & Present*. 109 p.204-230
52. Hall P. (1952) *The Social Services of Modern England*. London:Routledge & Kegan Paul Ltd
53. Evans CEL and Harper C. (2009) A history and review of school meal standards in the UK. *Journal of Human Nutrition and Dietetics*. 22 p.89-99
54. *The Education Act*.
http://www.legislation.gov.uk/ukpga/1980/20/pdfs/ukpga_19800020_en.pdf
55. Department of Health and Social Services. (1980) *The Black Report: Inequalities in Health*.
56. Gustafsson U. (2002) School Meals Policy: The Problem with Governing Children. *Social Policy & Administration*. 36 (6), p.685-697
57. *Department for Education. Excellence in Schools*.
<http://www.educationengland.org.uk/documents/wp1997/excellence-in-schools.html>
Accessed 10th November, 2014
58. School Meals Review Panel. (2005) *Turning the Tables. Transforming School Food: A report on the development and implementation of nutritional standards for school lunches*.
59. Nelson M, Bradbury J, Poulter J, McGee A, Msebele S and Jarvis L. (2004) *School Meals in Secondary Schools in England*. London:Department for Education and Skills
60. Nelson M, Nicholas J, Suleiman S, Davies O, Prior G, Hall L, Wreford S and Poulter J. (2006) *School meals in primary schools in England*. London:Department for Education and Skills
61. Nelson M, Lowes K and Hwang V. (2007) The contribution of school meals to food consumption and nutrient intakes of young people aged 4-18 years in England. *Public Health Nutrition*. 10 (7), p.652-662

62. Spence D. (2005) Jamie's School Dinners. *British Medical Journal*. 330 (678.1)
63. BBC NEWS. Oliver's school meal crusade goes on. <http://news.bbc.co.uk/go/pr/fr/-/1/hi/uk/5313882.stm> Accessed 14th April, 2013
64. School Food Trust. *A Guide to introducing the Government's food-based and nutrient-based standards for school lunches*.
www.childrensfoodtrust.org.uk/resources/guide-to-the-nutrient-based-standards
Accessed 28th March, 2012
65. World Food Programme. (2013) *State of School Feeding Worldwide*. Rome:World Food Programme
66. Department for Education and Skills. (2006) *Nutritional Standards for school lunches and other school food*. London:Department for Education and Skills
www.education.gov.uk/publications
67. HM Government. (1991) *The Health of the Nation*. London:The Stationery Office
68. HM Government. (1999) *Saving Lives: Our Healthier Nation*. London:The Stationery Office
69. Department of Health. (2008) *National Child Measurement Programme:2006/07 school year, headline results*.
70. HM Government. (2011) *Healthy Lives, Healthy People: Update and way forward*. London:HMSO
71. Grant MJ and Booth A. (2009) A typology of reviews: an analysis of 14 review types and associated methodologies. *Health Information and Libraries Journal*. 26 p.91-108
72. PRISMA.
<http://www.prisma-statement.org/statement.htm> Accessed 23 November, 2014
73. Mendoza JA, Watson K and Weber Cullen K. (2010) Change in Dietary Energy Density after Implementation of the Texas School Nutrition Policy. *Journal of the American Dietetic Association*. 110 p.434-440
74. Vereecken CA, Bobelijn K and Maes L. (2005) School food policy at primary and secondary schools in Belgium-Flanders:does it influence young people's food habits? *European Journal of Clinical Nutrition*. 59 p.271-277
75. Gould R, Russell J and Barker ME. (2006) School lunch menus and 11 to 12 year old children's food choice in three secondary schools in England-are the nutritional standards being met? *Appetite*. 46 (1), p.86-92
76. Gatenby LA. (2007) Nutritional content of school meals in Hull and the East Riding of Yorkshire: a comparison of two schools. *Journal of Human Nutrition and Dietetics*. 20 p.538-548
77. Martin CK, Thomson JL, LeBlanc MM, Stewart TM, Newton Jr RL, Han H, Sample A, Champagne CM and Williamson DA. (2010) Children in School Cafeterias Select Foods Containing More Saturated Fat and Energy than the Institute of Medicine Recommendations. *The Journal of Nutrition*. 140 p.1653-1660
78. Haroun D, Harper C, Wood L and Nelson M. (2010) The impact of the food-based and nutrient-based standards on lunchtime food and drink provision and consumption in primary schools in England. *Public Health Nutrition*. 14 (2), p.209-218

79. Nicholas J, Wood S, Harper C and Nelson M. (2013) The impact of the food-based and nutrient-based standards on lunchtime food and drink provision and consumption in secondary schools in England. *Public Health Nutrition*. 16 (6), p.1052-1065
80. Dresler-Hawke E, Whitehead D and Coad J. (2009) What are New Zealand children eating at school? A content analysis of consumed versus unconsumed food groups in a lunch box survey. *Health Education Journal*. 68 (1), p.3-13
81. Conway TL, Sallis JF, Pelletier RL, Powers HS, Marshall SJ, Zive MM and Elder JP. (2002) What Do Middle School Children Bring in Their Bag Lunches? *Preventive Medicine*. 34 p.422-427
82. Evans CEL, Greenwood DC, Thomas JD and Cade JE. (2010) A cross-sectional survey of children's packed lunches in the UK: food-and nutrient-based results. *Journal of Epidemiology and Community Health*. 64 p.977-983
83. Evans CEL, Cleghorn CL, Greenwood DC and Cade JE. (2010) A comparison of British school meals and packed lunches from 1990 to 2007: meta-analysis by lunch type. *British Journal of Nutrition*. 104 p.474-487
84. Pearce J, Harper C, Haroun D, Wood L and Nelson M. (2011) Key differences between school lunches and packed lunches in primary schools in England in 2009. *Public Health Nutrition*. 14 (8), p.1507-1510
85. Pearce J, Wood L and Nelson M. (2012) Lunchtime food and nutrient intakes of secondary-school pupils: a comparison of school lunches and packed lunches following the introduction of mandatory food-based standards for school lunch. *Public Health Nutrition*. 16 (6), p.1126-1131
86. Stevens L, Nicholas J, Wood L and Nelson M. (2012) School lunches v. packed lunches: a comparison of secondary schools in England following the introduction of compulsory food standards. *Public Health Nutrition*. 16 (6), p.1037-1042
87. Golley R, Pearce J and Nelson M. (2010) Children's lunchtime food choices following the introduction of food-based standards for school meals: observations from six primary schools in Sheffield. *Public Health Nutrition*. 14 (2), p.271-278
88. Hur I, Burgess-Champoux T and Reicks M. (2011) Higher Quality Intake from School Lunch Meals Compared with Bagged Lunches. *Infant, Child, & Adolescent Nutrition*. 3 p.70-75
89. Taylor JP, Hernandez KJ, Caiger JM, Giberson D, MacLellan D, Sweeney-Nixon M and Veugelers P. (2012) Nutritional quality of children's school lunches: differences according to food source. *Public Health Nutrition*. 15 (12), p.2259-2264
90. Rogers IS, Ness AR, Hebditch K, Jones LR and Emmett PM. (2007) Quality of food eaten in English primary schools: school dinners vs packed lunches. *European Journal of Clinical Nutrition*. 61 p.856-864
91. Rees GA, Richards CJ and Gregory J. (2008) Food and nutrient intakes of primary school children: a comparison of school meals and packed lunches. *Journal of Human Nutrition and Dietetics*. 21 p.420-427
92. Prynne CJ, Handford C, Dunn V, Bamber D, Goodyer IM and Stephen AM. (2011) The quality of midday meals eaten at school by adolescents: school lunches compared with packed lunches and their contribution to total energy and nutrient intakes. *Public Health Nutrition*. 165 (7), p.603-609

93. Cullen KW, Watson KB and Fithian AR. (2009) The impact of school socioeconomic status on student lunch consumption after implementation of the Texas Public School Nutrition Policy. *Journal of School Health*. 79 p.525-531
94. Harrison F, Jennings A, Jones A, Welch A, van Sluijs E, Griffin S and Cassidy A. (2011) Food and drink consumption at schooltime: the impact of lunch type and contribution to overall intake in British 9-10-year-old children. *Public Health Nutrition*. doi.10.1017/s1368980011002321. Epub2011 Sep 22
95. Stevens L. and Nelson M. (2011) The contribution of school meals and packed lunch to food consumption and nutrient intakes in UK primary school children from a low income population. *Journal of Human Nutrition and Dietetics*. 24 p.223-232
96. Clark MA and Fox MK. (2009) Nutritional Quality of the Diets of US Public School Children and the Role of the School Meals Programs. *Journal of the American Dietetic Association*. 109 S44-S56
97. Fung C, Mclsaac JLD, Kuhle S, Kirk SFL and Veugelers PJ. (2013) The impact of a population-level school food and nutrition policy on dietary intake and body weights of Canadian children. *Preventive Medicine*. 57 p.934-940
98. Tilles-Trikkonen T, Pentikainen S, Lappi J, Karhunen L, Potanen K and Mykkanen H. (2011) The quality of school lunch consumed reflects overall eating patterns in 11-16-year old schoolchildren in Finland. *Public Health Nutrition*. 14 (12), p.2092-2098
99. Adamson AJ, Griffiths JM, Carlin LE, Barton KL, Wrieden WL, Matthews JNS and Mathers JC. (2003) FAST: Food Assessment in Schools Tool. *Proceedings of the Nutrition Society*. 62 (1a), 84A
100. *Directgov.co.uk*.
www.direct.gov.uk/en/Parents/Schoolslearninganddevelopment/SchoolLife/DG_401608
9 Accessed 29th August, 2012
101. Hackett AF, Rugg-Gunn AJ and Appleton DR. (1983) Use of a dietary diary and interview to estimate the food intake of children. *Human Nutrition:Applied Nutrition*. 37 (4), p.293-300
102. Hackett AF, Rugg-Gunn AJ, Appleton DR, Eastoe JE and Jenkins GN. (1984) A 2-year longitudinal nutritional survey of 405 Northumberland children initially aged 11.5 years. *British Journal of Nutrition*. 51 (1), p.67-75
103. Adamson AJ, Rugg-Gunn AJ, Butler TJ, Appleton D.R and Hackett AF. (1992) Nutritional intake, height and weight of 11-12-year-old Northumbrian children in 1990 compared with information obtained in 1980. *British Journal of Nutrition*. 68 (3), p.543-563
104. Fletcher ES, Rugg-Gunn AJ, Matthews JNS, Hackett A, Moynihan PJ, Mathers JC and Adamson AJ. (2004) Changes over 20 years in macronutrient intake and body mass index in 11- to 12-year old adolescents living in Northumberland. *British Journal of Nutrition*. 92 (2), p.321-333
105. Rugg-Gunn AJ, Fletcher ES, Matthews JNS, Hackett AF, Moynihan PJ, Kelly SAM, Mathers JC and Adamson AJ. (2007) Changes in consumption of sugars by English adolescents over 20 years. *Public Health Nutrition*. 10 (4), p.354-363
106. Hossack A. (2009) Tracking and change in diet and adiposity from early to late adolescence. *Unpublished thesis*.

107. Foster E, Hawkins A and Adamson AJ. (2010) *Young Person's Food Atlas*. Food Standards Agency
108. Hackett AF, Appleton DR, Rugg-Gunn AJ and Eastoe JE. (1985) Some influences on the measurement of food intake during a dietary survey of adolescents. *Human Nutrition:Applied Nutrition*. 39A p.167-177
109. Wrieden WL, Longbottom PJ, Adamson AJ, Ogston SA, Payne A, Haleem MA and Barton KL. (2008) Estimation of typical food portion sizes for children of different ages in Great Britain. *British Journal of Nutrition*. 99 (6), p.1344-1353
110. Food Standards Agency. (2002) *McCance and Widdowson's the Composition of Foods, Sixth Summary Edition*. Cambridge:The Royal Society of Chemistry
111. *Communities and Local Government. Indices of Deprivation 2007*.
<http://webarchive.nationalarchives.gov.uk/+http://www.communities.gov.uk/communities/neighbourhoodrenewal/deprivation/deprivation07/> Accessed 30th June, 2011
112. Warren E, Parry O, Lynch R and Murphy S. (2008) 'If I don't like it then I can choose what I want': Welsh school children's accounts of preference for and control over food choice. *Health Promotion International*. 23 (2), p.144-151
113. Gustafsson U. (2004) The privatisation of risk in school meals policies. *Health, Risk & Society*. 6 (1), p.53-65
114. Stead M, McDermott L, Mackintosh AM and Adamson AJ. (2011) Why healthy eating is bad for young people's health:identity, belonging and food. *Social Science and Medicine*. 72 (7), p.1131-1139
115. Moolchan ET and Mermelstein R. (2002) Research on Tobacco Use Among Teenagers: Ethical Challenges. *Journal of Adolescent Health*. 30 p.409-417
116. Henry KL, Smith EA and Hopkins AM. (2002) The effect of active parental consent on the ability to generalize the results of an alcohol, tobacco, and other drug prevention trial to rural adolescents. *Evaluation Review*. 26 (2), p.645-655
117. Unger JB, Gallagher P, Palmer PH, Baezconde-Garbanti L, Trinidad DR, Cen S and Johnson CA. (2004) No News is Bad News:Characteristics of adolescents who provide neither parental consent nor refusal for participation in school-based survey research. *Evaluation Review*. 28 (1), p.52-63
118. Santelli J and Rogers AS. (2002) Parental Permission, Passive Consent, and "Children" in Research. *Journal of Adolescent Health*. 31 p.303-304
119. Han JC, Lawlor DA and Kimm SYS. (2010) Childhood obesity. *Lancet*. 375 p.1737-48
120. Swinburn BA, Sacks G, Hall KD, McPherson K, Finegood DT, Moodie ML and Gortmaker SL. (2011) The global obesity epidemic: shaped by drivers and local environments. *Lancet*. 378 p.804-814
121. Driessen CE, Cameron AJ, Thornton LE, Lai SK and Barnett LM. (2014) Effect of changes to the school food environment on eating behaviours and/or body weight in children:a systematic review. *Obesity Reviews*. doi:10.1111/obr.12224
122. Waters E, de Silva-Sanigorski A, Burford BJ, Brown T, Campbell KJ, Gao Y, Armstrong R, Prosser L and Summerbell CD. (2011) Interventions for preventing obesity in children. *Cochrane Library*.

123. Spence S, White M, Adamson AJ and Matthews JNS. (2014) Does the use of passive or active consent affect consent or completion rates, or dietary data quality? Repeat cross-sectional survey among school children aged 11-12 years. *BMJ Open*. 4:e006457.doi:10.1136/bmjopen-2014-006457
124. Monaghan NP, Jones SJ and Morgan MZ. (2011) Do parents of children with caries choose to opt-out of positive consent dental surveys in Wales? *British Dental Journal*. 201(2):E1.doi:10.1038/sj.bdj.2011.26
125. Dent CW, Galaif J, Sussman S, Stacy A, Burtun D and Flay BR. (1993) Demographic, Psychosocial and behavioral differences in samples of actively and passively consented adolescents. *Addictive Behaviors*. 18 p.51-56
126. Craig P, Dieppe P, Macintyre S, Michie S, Nazareth I and Petticrew M. (2008) Developing and evaluating complex interventions: the new Medical Research Council guidance. *British Medical Journal*. 337 (7676), p.979-983
127. Moore G, Audrey S, Barker M, Bond L, Bonell C, Cooper C, Hareman W, Moore L, O'Cathain A, Tinati T, Wright D and Baird J. (2014) Process evaluation in complex public health intervention studies: the need for guidance. *Journal of Epidemiology and Community Health*. 68 p.101-102
128. Rychetnik L, Frommer M, Hawe P and Shiell A. (2002) Criteria for evaluating evidence on public health interventions. *Journal of Epidemiology and Community Health*. 56 p.119-127
129. Atkins L and Michie S. (2013) Changing eating behaviour: What can we learn from behavioural science? *Nutrition Bulletin*. 38 p.30-35
130. Campbell M, Fitzpatrick R, Haines A, Kinmonth AL, Sandercock P, Spiegelhalter D and Tyrer P. (2000) Framework for design and evaluation of complex interventions to improve health. *British Medical Journal*. 321 p.694-696
131. Nutbeam D. (1998) Evaluating Health Promotion-Progress, Problems and Solutions. *Health Promotion International*. 13 p.27-44
132. Hawe P, Shiell A and Riley T. (2004) Complex interventions: how out of "control" can a randomised controlled trial be? *British Medical Journal*. 328 p.1561-1563
133. Taylor JP, McKenna ML and Butler GP. (2010) Monitoring and Evaluating School Nutrition and Physical Activity Policies. *Canadian Journal of Public Health*. 101 S24-S27
134. Petticrew M, Chalabi Z and Jones DR. (2012) To RCT or not to RCT: deciding when 'more evidence is needed' for public health policy and practice. *Journal of Epidemiology and Community Health*. 66 p.391-396
135. Smith RD and Petticrew M. (2010) Public health evaluation in the twenty-first century: time to see the wood as well as the trees. *Journal of Public Health*. 32 (1), p.2-7
136. Achana F, Hubbard S, Sutton A, Kendrick D and Cooper N. (2014) An exploration of synthesis methods in public health evaluations of interventions concludes that the use of modern statistical methods would be beneficial. *Journal of Clinical Epidemiology*. 67 (4), p.376-390
137. House of Commons Health Committee. (2009) *Health Inequalities. Third Report of Session*. London:Stationery Office

138. Innvaer S, Vist G, Trommald M and Oxman A. (2002) Health policy-makers' perception of their use of evidence: a systematic review. *Journal of Health Services Research & Policy*. 7 p.239-244
139. Buse K, Mays N and Walt G. (2005) *Making Health Policy*. Berkshire:Open University Press, McGraw-Hill Education
140. NICE. *Behaviour Change: the principles for effective interventions*. www.nice.org.uk/guidance/ph6/Chapter/2-considerations Accessed 24th October, 2014
141. Ogilvie D, Cummins S, Petticrew M, White M, Jones A and Wheeler K. (2011) Assessing the Evaluability of Complex Public Health Interventions: Five Questions for Researchers, Funders, and Policymakers. *The Millbank Quarterly*. 89 (2), p.206-225
142. Craig P, Cooper C, Gunnell D, Haw S, lawson K, Macintyre S, Ogilvie D, Petticrew M, Reeves B, Sutton M and Thompson S. (2012) Using natural experiments to evaluate population health interventions: new Medical Research Council guidance. *Journal of Epidemiology and Community Health*. doi:10.1136/jech-2011-200375
143. Berwick DM. (2008) The science of improvement. *Journal of the American Medical Association*. 299 p.1182-1184
144. Glasgow RE, Lichtenstein E and Marcus AC. (2003) Why don't we see more translation of health promotion research to practice? Rethinking the efficacy-to-effectiveness transition. *American Journal of Public Health*. 93 p.1261-1267
145. Bonsmann SSG, Kardakis T, Wollgast J, Nelson M and Caldeira S. (2014) *Mapping of National School Food Policies across the EU28 plus Norway and Switzerland*. Luxembourg:Publications Office of the European Union
146. *EU action plan*. http://ec.europa.eu/health/nutrition_physical_activity/docs/childhoodobesity_actionplan_2014_2020_en.pdf Accessed 23rd October, 2014
147. Gelli A and Espejo F. (2012) School feeding, moving from practice to policy: reflections on building sustainable monitoring and evaluation systems. *Public Health Nutrition*. 16 (6), p.995-999
148. Nelson M and Breda J. (2012) School food research: building the evidence base for policy. *Public Health Nutrition*. 16 (6), p.958-967
149. Bundy DA, Drake LJ and Burbano C. (2013) School food, politics and child health. *Public Health Nutrition*. 16 (6), p.1012-9
150. Pike J. (2010) 'I don't have to listen to you! You're just a dinner lady!': power and resistance at lunchtimes in primary schools. *Children's Geographies*. 8 (3), p.275-287
151. Moore SN, Murphy S and Moore L. (2011) Health improvement, nutrition-related behaviour and the role of school meals: the usefulness of a socio-ecological perspective to inform policy design, implementation and evaluation. *Critical Public Health*. 21 (4), p.441-454
152. Nelson M. *The impact of school food standards on diet, behaviour and growth*. <http://www.childrensfoodtrust.org.uk/assets/school-food-review-documents/Presentation%20-%20the%20impact%20of%20evidence-based%20policy.pdf> Accessed November, 2014

153. Moore SN, Murphy S, Tapper K and Moore L. (2010) The social, physical and temporal characteristics of primary school dining halls and their implications for children's eating behaviours. *Health Education*. 110 (5), p.399-411
154. Wills WJ, Backett-Milburn K, Gregory S and Lawton J. (2005) The influence of the secondary school setting on the food practices of young teenagers from disadvantaged backgrounds in Scotland. *Health Education Research*. 20 (4), p.458-465
155. Williams LK, Veitch J and Ball K. (2011) What helps children eat well? A qualitative exploration of resilience among disadvantaged families. *Health Education Research* 26 (2), p.296-307
156. Pike J. (2008) Foucault, space and primary school dining rooms. *Children's Geographies*. 6 (4), p.413-442
157. *School Food Plan*. <http://whatworkswell.schoolfoodplan.com/> 13th February, 2014
158. Cooke L. (2007) The importance of exposure for healthy eating in childhood: a review. *Journal of Human Nutrition and Dietetics*. 20 p.294-301
159. Yamamoto JA, Yamamoto JB, Yamamoto BE and Yamamoto LG. (2005) Adolescent fast food and restaurant ordering behavior with and without calorie and fat content menu information. *Journal of Adolescent Health*. 37 (5), p.397-402
160. Waterlander WE, Mhurchu CN and Steenhuis IHM. (2014) Effects of a price increase on purchases of sugar sweetened beverages. Results from a randomized controlled trial. *Appetite*. 78C p.32-39
161. Thow AM, Downs S and Jan S. (2014) A systematic review of the effectiveness of food taxes and subsidies to improve diets: Understanding the recent evidence. *Nutrition Reviews*. 72 (9), p.551-565
162. Darmon N, Lacroix A, Muller L and Ruffieux B. (2014) Food price policies improve diet quality while increasing socioeconomic inequalities in nutrition. *International Journal of Behavioral Nutrition and Physical Activity*. 11 (66), doi:10.1186/1479-5868-11-66
163. Comans TA, Whitty JA, Hills AP, Kendall E, Turkstra E, Gordon LG, Byrnes JM and Scuffham PA. (2013) The cost-effectiveness and consumer acceptability of taxation strategies to reduce rates of overweight and obesity among children in Australia: study protocol. *BMC Public Health*. 13 p.1182-1187
164. *BBC NEWS*. All infants in England to get free school lunches. <http://www.bbc.co.uk/news/uk-politics-24132416> Accessed 17th September, 2013
165. *School Food Plan*. www.schoolfoodplan.com Accessed 2nd December, 2013
166. Kitchen S, Tanner E, Brown V, Payne C, Crawford C, Dearden L, Greaves E and Purdon S. Education Department for (2010) *Evaluation of the Free School Meals Pilot: Impact Report* London:Department for Education https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/184047/DFE-RR227.pdf
167. *Children and Families Act*. <http://www.legislation.gov.uk/ukpga/2014/6/section/106/enacted> Accessed 23rd October, 2014

Appendices

A. Ethics approval letter



**Faculty Research Strategy Group
Faculty of Medical Sciences**

Newcastle University
The Medical School
Framlington Place
Newcastle upon Tyne
NE2 4HH United Kingdom

FACULTY OF MEDICAL SCIENCES: ETHICS COMMITTEE

22 January 2008

Dr Ashley Adamson
Human Nutrition Research Centre
M1.151 William Leech Building
Medical School

Dear Dr Adamson

Title: The process and impact of change in school food policy on food and nutrient intake both in and outside of school

Application No: 000011/2007

On behalf of the Faculty of Medical Sciences Ethics Committee, I am writing to confirm that the ethical aspects of your proposal have been considered and your study has been given favourable ethical approval.

Best wishes,

Yours sincerely

A handwritten signature in black ink that reads "Marjorie Holbrough".

Marjorie Holbrough

On behalf of Faculty Ethics Committee

cc. Professor T E Cawston, Dean of Research
Ms Lois Neal, Assistant Registrar (Research Strategy)

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The University of Newcastle upon Tyne trading as Newcastle University



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B. Parent information letter (primary schools 2008-09)

Dear Parent / Guardian

Newcastle School Food Study

Children in Key Stage 1 from your child's school took part in a study last year with the aim of finding out about their eating habits. We are delighted that your child's school has agreed to participate in the second stage of this study.

Whether your child did or didn't take part last year, it doesn't matter; we would like them to take part this year. The study is supported by the Department of Health and has been approved by Newcastle Education Authority and by Newcastle University's Research Ethics Committee.

What we would like you to do:

- Record everything your child eats and drinks at home for four days. Your child will be given a recording booklet which has a simple tick list for completion and we request that you complete this record during the times your child is not at school. We will employ trained observers to complete this record during the time your child is at school.

What we would like your child to do:

- While taking part in the study, we would like your child to bring the recording booklet to school every morning and take it home in the afternoon.
- Your child will be measured for height, waist circumference, weight and body composition by the nutritionist (Suzanne Spence) working on the study. These measurements will be taken in private and all the information collected will be confidential. You will be invited to attend if you wish.

What your child will gain:

- Previously children have enjoyed participating in this study.
- A certificate on completion of the food diary.

Your child's school will receive book tokens to the value of £1 for each child participating in the study.

This study will take minimum time and effort and should not interfere with school work. Your child is free to leave the study at any time without the need to give any reason. If you have any queries about the study, please contact me (Ashley Adamson) at the above address, or ring me on the phone number below.

Please complete and sign the consent form on the following page and return to school as soon as possible.

Yours sincerely,



Ashley Adamson (Dr)
Lead Investigator
Senior Lecturer at Newcastle University
Tel. 0191 2225276



C. Parent consent form (primary schools 2008-09)

CONSENT FORM

School Food Study

ID No.

I have read the Recruitment Letter explaining how my child will be involved in the study and have had time to consider it. I understand that participation is voluntary and that my child is free to withdraw at anytime, without giving any reason.

Name of child Male / female* Date of birth ___ / ___ / ____

Class

School

I agree/do not agree* to my child taking part in the study

Signed (parent/guardian)

Name of parent/guardian

Date

I agree/do not agree* to take part in the study

Signed (child)

Name of child

Date

*please delete as appropriate

Name: Mr/Mrs/Ms.....

Address.....

Post Code

Telephone no. (day)

Telephone no. (evening)

Mobile phone no

The only medical information we need to know for this study is does your child have a pacemaker?
yes/no*

*please delete as appropriate

We need to know this because the weighing scale we will use is electrical,
if your child has a pacemaker we will ensure that we use a non-electrical scale to weigh them.

PLEASE RETURN THIS FORM TO SCHOOL TOMORROW



D. Letter to school heads (middle schools for 2009-10)



Dear

Northumberland School Food Study – your views please

Thank you once again for agreeing to participate in the 2009/10 Northumberland School Food Study. This is a vital stage of the study; your agreement means we will have unique information on the food intake of 11-12 year olds in Northumberland from 1980, 1990, 2000, 2007 and 2010.

I am contacting you to seek your advice and opinion about consent for participation in the 2009/10 study. You will be aware that in previous surveys we have required active parental opt-in consent and child assent for participation; this has been a requirement of ethical approval awarded to the study.

We are concerned to maximise participation. In the 2007 survey only 29% of eligible children took part in the study in comparison with 65-69% of children in the previous studies in 1980, 1990 and 2000.

From discussions with some of the Head Teachers during the recruitment process in 2007 it was suggested that the requirement for parental active opt-in consent effectively excludes some children who fail to benefit from participation in the study. These children are therefore not represented in the data collected. A general view was that this is not due to parents' objection to participation but rather non-return of the consent form. Indeed in the 2007 survey we had very few active non-consents.

Taking these comments on board and given that we are concerned with maximising participation and ultimately ensuring representativeness of the results, we have written to the Newcastle University Ethics Committee to request that they consider granting approval for **Opt-out recruitment** rather than **Opt-in**. This would mean all children in Year 7 would be asked to participate as in previous years, and that we would assume all children wished to participate unless children and/or parents actively chose not to participate by returning the **Opt-out** form. Of course children could effectively exclude themselves by non-completion of dietary diaries and would be free to leave the study at any time. We will also offer a token of thanks in the form a £10 voucher [mobile top-up or i-tunes voucher] for children completing all aspects of the study and a book token to each school to the value of £1 for each child completing the study.

The Newcastle University Ethics Committee has indicated that they are willing to consider this approach but that they would like to have the views of Head Teachers and School Governors to inform their deliberations. I am writing to seek your views.

We seek to minimise the burden on you imposed by this consultation. We have prepared a pro forma (attached) to record your views and return to us either by email or in writing. We would be grateful if you could consider this and seek views of Governors. If you have any questions or would like to discuss this further please do not hesitate to contact me. Your assistance is very much appreciated.

With thanks

A handwritten signature in black ink that reads 'Ashley J. Adamson' followed by a horizontal line.

Dr Ashley J Adamson
Principal Investigator for the Northumberland Food Study

A.J.Adamson@ncl.ac.uk

0191 222 5276

Consent for participation in the Northumberland School Food Study

Newminster Middle School

Please indicate your views by ticking one of the boxes below:

We have discussed the issue of active opt-in or opt-out consent

- We **DO** support an **opt-out** consent procedure for the 2009/2010 Northumberland Food Study. Only children who return forms indicating that they DO NOT wish to participate will be excluded.
- We **DO NOT** support opt-out consent procedure for 2009/2010 Northumberland Food Study and would prefer parents continued to give active consent for participation.

Signatures:

Head teacher _____ Date _____

Governor _____ Date _____

Please use this space for any comments (continue on reverse or on a separate sheet if required)

Your response by 10th June 2009 would be very much appreciated

Please note if you are returning this form electronically - electronic signature will insert as a picture file

If returning by mail please return to Dr A Adamson, Human Nutrition Research Centre, M1.151 Leech building, Faculty of Medical Sciences, Newcastle University. Framlington Place. Newcastle NE2 4HH

E. Ethics approval letter for amendment in consent procedure



9 July 2009

Dr Ashley Adamson
Human Nutrition Research Centre
M1.151 William Leech Building
Medical School

**Faculty Research Strategy Group
Faculty of Medical Sciences**

Newcastle University
The Medical School
Framlington Place
Newcastle upon Tyne
NE2 4HH United Kingdom

FACULTY OF MEDICAL SCIENCES: ETHICS COMMITTEE

Dear Ashley

Amendment (16/05/09) to: The process and impact of change in school food policy on food and nutrient intake both in and outside of school

Application No: 00011/2009

On behalf of the Faculty of Medical Sciences Ethics Committee, I am writing to confirm that the ethical aspects of the amendment to your proposal have been considered and your study has been given favourable ethical approval.

Best wishes,

Yours sincerely

A handwritten signature in blue ink that reads "M. Holbrough".

Marjorie Holbrough

On behalf of Faculty Ethics Committee

cc. Professor T E Cawston, Dean of Research
Ms Lois Neal, Assistant Registrar (Research Strategy)

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F. Parent information letter and consent form (middle schools 2009-10)

Dear Parent / Guardian

Northumberland Schools Food Study

Since 1980 Year 7 children from your child's school have been part of the Northumberland School Food Study, which looks at children's eating habits and how these have changed. No other studies of children's diets and how they have changed exist. These studies were important nationally as well as in Northumberland and helpful in health promotion in this region. We are delighted your child's school has once again agreed to be involved in this study, and would like to invite your child to take part.

What the study involves:

- Your child writing down everything they eat and drink for three days; followed by a brief interview with the nutritionist (Suzanne Spence) to clarify what they have written. This will be done on two occasions, once in the Autumn/Winter term and once in the Spring/Summer term.
- One measurement of your child's height and weight in 2010.
- Collecting some information from you about your occupation.

The interview with the nutritionist (Suzanne Spence) and measurement of height and weight will be private, and all the information will be confidential.

Previous studies like this have found it helpful to communicate with the child by text messaging. When your child is given a diary they will be asked for a mobile telephone number to send a reminder text to start their diary and attend interview.

Why your child should take part:

- Previously children have enjoyed writing down what they eat and taking part in this study.
- On completion of two 3-day food diaries they will receive a **certificate of achievement and a £10 voucher**.
- They will be making a valuable contribution to their school's involvement. For each child that completes the study the school will receive book tokens to the value of £1 per child.
- After the research is complete we will return to school to tell the children who took part, how their diet compared with diets of Year 7 children over the last 30 years.

This study will not take much time or effort and should not interfere with school work. Your child is free to leave the study at any time without the need to give any reason. If you have any queries about the study, please contact me (Ashley Adamson) at the above address, or, e-mail or ring me on the phone number below.




Yours sincerely,



Prof Ashley Adamson
Lead investigator
Senior Lecturer at Newcastle University
Tel: 0191 2225276
E-mail: a.j.adamson@ncl.ac.uk



G. Dietary data collection tool (primary schools)

	_____ Class
	_____ Name
	 Newcastle School Food Study
	Draw it here! What is your favourite food?
 Newcastle School Food Study	<h2>This food diary belongs to</h2> <p>Name _____</p> <p>Class _____</p> <p>ID No. _____</p>
 Newcastle University	Human Nutrition Research Centre M1, 151 1st Floor William Leech Building Framlington Place Newcastle upon Tyne NE2 4HH Tel: 0191 222 5276

Day 2 Thursday


- School Lunch
- Packed Lunch

6.00am - 9.00am Time slot 1	<input type="checkbox"/> White bread or toast <input type="checkbox"/> Wholemeal bread or toast <input type="checkbox"/> Margarine <input type="checkbox"/> Butter <input type="checkbox"/> Jam or preserves <input type="checkbox"/> Weetabix <input type="checkbox"/> Cornflakes <input type="checkbox"/> Frosties	<input type="checkbox"/> Coco Pops <input type="checkbox"/> Rice Krispies <input type="checkbox"/> Milk full-fat with cereal <input type="checkbox"/> Milk, semi-skimmed with cereal <input type="checkbox"/> Banana <input type="checkbox"/> Egg <input type="checkbox"/> Yoghurt <input type="checkbox"/> Sugar	<input type="checkbox"/> Biscuits—not chocolate <input type="checkbox"/> Biscuits—chocolate <input type="checkbox"/> Orange juice, unsweetened <input type="checkbox"/> Apple juice, unsweetened <input type="checkbox"/> Milk, full-fat drink <input type="checkbox"/> Milk, semi-skimmed drink <input type="checkbox"/> Squash—reduced sugar	<input type="checkbox"/> Squash <input type="checkbox"/> Tea with milk <input type="checkbox"/> Water Others _____ _____ _____
9.01am - 11.00am Time slot 2	<input type="checkbox"/> White bread or toast <input type="checkbox"/> Wholemeal bread or toast <input type="checkbox"/> Margarine <input type="checkbox"/> Butter <input type="checkbox"/> Jam or preserves <input type="checkbox"/> Apple <input type="checkbox"/> Banana <input type="checkbox"/> Pear	<input type="checkbox"/> Tangerine, mandarin, satsuma <input type="checkbox"/> Crisps or savoury snacks <input type="checkbox"/> Biscuits—not chocolate <input type="checkbox"/> Biscuits—chocolate <input type="checkbox"/> Chocolate bar <input type="checkbox"/> Chocolate sweets <input type="checkbox"/> Sweets (not chocolate)	<input type="checkbox"/> Orange juice, unsweetened <input type="checkbox"/> Apple juice, unsweetened <input type="checkbox"/> Milk, full-fat drink <input type="checkbox"/> Milk, semi-skimmed drink <input type="checkbox"/> Squash—reduced sugar <input type="checkbox"/> Squash <input type="checkbox"/> Fizzy drink <input type="checkbox"/> Diet fizzy drink	<input type="checkbox"/> Water Others _____ _____ _____
11.01am - 2.00pm Time slot 3	<input type="checkbox"/> White bread or toast <input type="checkbox"/> Wholemeal bread or toast <input type="checkbox"/> Margarine <input type="checkbox"/> Butter <input type="checkbox"/> Cheese <input type="checkbox"/> Cheese spread / triangle <input type="checkbox"/> Baked beans <input type="checkbox"/> Fish fingers <input type="checkbox"/> Ham <input type="checkbox"/> Chicken or turkey (not nuggets) <input type="checkbox"/> Sausage roll <input type="checkbox"/> Tuna, tinned <input type="checkbox"/> Eggs, boiled <input type="checkbox"/> Pasta, tinned, in tomato sauce	<input type="checkbox"/> Oven chips <input type="checkbox"/> Chips—fried <input type="checkbox"/> Potatoes—other <input type="checkbox"/> Peas <input type="checkbox"/> Sweetcorn <input type="checkbox"/> Carrots <input type="checkbox"/> Cucumber <input type="checkbox"/> Tomato <input type="checkbox"/> Crisps or savoury snacks <input type="checkbox"/> Ketchup <input type="checkbox"/> Gravy <input type="checkbox"/> Apple <input type="checkbox"/> Banana <input type="checkbox"/> Tangerine, mandarin, satsuma	<input type="checkbox"/> Grapes <input type="checkbox"/> Strawberries <input type="checkbox"/> Raisins <input type="checkbox"/> Biscuits—not chocolate <input type="checkbox"/> Biscuits—chocolate <input type="checkbox"/> Yoghurt / fromage frais <input type="checkbox"/> Cake or sweet pastry <input type="checkbox"/> Custard <input type="checkbox"/> Chocolate bar <input type="checkbox"/> Sweets (not chocolate) <input type="checkbox"/> Orange juice, unsweetened <input type="checkbox"/> Squash—reduced sugar <input type="checkbox"/> Squash	<input type="checkbox"/> Fizzy drink <input type="checkbox"/> Diet fizzy drink <input type="checkbox"/> Water Others _____ _____ _____
2.01pm - 4.00pm Time slot 4	<input type="checkbox"/> White bread or toast <input type="checkbox"/> Margarine <input type="checkbox"/> Butter <input type="checkbox"/> Apple <input type="checkbox"/> Banana <input type="checkbox"/> Pear <input type="checkbox"/> Tangerine, mandarin, satsuma <input type="checkbox"/> Crisps or savoury snacks	<input type="checkbox"/> Biscuits—not chocolate <input type="checkbox"/> Biscuits—chocolate <input type="checkbox"/> Chocolate bar <input type="checkbox"/> Chocolate sweets <input type="checkbox"/> Sweets (not chocolate) <input type="checkbox"/> Ice lolly <input type="checkbox"/> Cheese <input type="checkbox"/> Tomato ketchup	<input type="checkbox"/> Yoghurt / Fromage frais <input type="checkbox"/> Orange juice, unsweetened <input type="checkbox"/> Milk, full-fat drink <input type="checkbox"/> Milk, semi-skimmed drink <input type="checkbox"/> Squash—reduced sugar <input type="checkbox"/> Squash <input type="checkbox"/> Fizzy drink	<input type="checkbox"/> Diet fizzy drink <input type="checkbox"/> Water Others _____ _____ _____
4.01pm - 7.00pm Time slot 5	<input type="checkbox"/> White bread or toast <input type="checkbox"/> Margarine <input type="checkbox"/> Butter <input type="checkbox"/> Apple <input type="checkbox"/> Banana <input type="checkbox"/> Grapes <input type="checkbox"/> Strawberries <input type="checkbox"/> Oven chips <input type="checkbox"/> Chips—fried <input type="checkbox"/> Boiled potatoes <input type="checkbox"/> Potatoes—other <input type="checkbox"/> Carrots <input type="checkbox"/> Peas <input type="checkbox"/> Sweetcorn <input type="checkbox"/> Cucumber	<input type="checkbox"/> Tomato <input type="checkbox"/> Broccoli <input type="checkbox"/> Sausages <input type="checkbox"/> Pasta, boiled <input type="checkbox"/> Pasta, tinned in tomato sauce <input type="checkbox"/> Fish fingers <input type="checkbox"/> Chicken or turkey nuggets <input type="checkbox"/> Chicken or turkey (not nuggets) <input type="checkbox"/> Pizza <input type="checkbox"/> Baked beans <input type="checkbox"/> Cheese <input type="checkbox"/> Boiled rice <input type="checkbox"/> Ham <input type="checkbox"/> Chapatti <input type="checkbox"/> Dhal	<input type="checkbox"/> Gravy <input type="checkbox"/> Tomato ketchup <input type="checkbox"/> Yoghurt / fromage frais <input type="checkbox"/> Crisps or savoury snacks <input type="checkbox"/> Biscuits—not chocolate <input type="checkbox"/> Biscuits—chocolate <input type="checkbox"/> Cake or sweet pastry <input type="checkbox"/> Chocolate bar <input type="checkbox"/> Pizza <input type="checkbox"/> Chocolate sweets <input type="checkbox"/> Sweets (not chocolate) <input type="checkbox"/> Ice cream <input type="checkbox"/> Orange juice, unsweetened <input type="checkbox"/> Apple juice, unsweetened <input type="checkbox"/> Milk, full-fat drink	<input type="checkbox"/> Milk, semi-skimmed drink <input type="checkbox"/> Squash—reduced sugar <input type="checkbox"/> Squash <input type="checkbox"/> Fizzy drink <input type="checkbox"/> Diet fizzy drink <input type="checkbox"/> Tea with milk <input type="checkbox"/> Water Others _____ _____ _____
7.01pm - 11.00pm Time slot 6	<input type="checkbox"/> White bread or toast <input type="checkbox"/> Margarine <input type="checkbox"/> Butter <input type="checkbox"/> Jam <input type="checkbox"/> Apple <input type="checkbox"/> Banana <input type="checkbox"/> Tangerine, mandarin, satsuma <input type="checkbox"/> Oven chips <input type="checkbox"/> Chips—fried <input type="checkbox"/> Cheese	<input type="checkbox"/> Pasta, boiled <input type="checkbox"/> Boiled rice <input type="checkbox"/> Chapatti <input type="checkbox"/> Dhal <input type="checkbox"/> Tomato Ketchup <input type="checkbox"/> Crisps or savoury snacks <input type="checkbox"/> Biscuits—not chocolate <input type="checkbox"/> Biscuits—chocolate <input type="checkbox"/> Sugar <input type="checkbox"/> Chocolate bar	<input type="checkbox"/> Chocolate sweets <input type="checkbox"/> Sweets (not chocolate) <input type="checkbox"/> Ice lollies <input type="checkbox"/> Yoghurt / fromage frais <input type="checkbox"/> Orange juice, unsweetened <input type="checkbox"/> Milk, full-fat drink <input type="checkbox"/> Milk, semi-skimmed drink <input type="checkbox"/> Drinking chocolate powder <input type="checkbox"/> Milk shake powder	<input type="checkbox"/> Squash - reduced sugar <input type="checkbox"/> Squash <input type="checkbox"/> Fizzy drinks <input type="checkbox"/> Diet fizzy drinks <input type="checkbox"/> Tea with milk <input type="checkbox"/> Water Others _____ _____ _____

H. Dietary data collection tool (middle schools)

If you want to you can use this space to write or draw what you think about your food during the three days.

Northumberland Schools Food Study



Human Nutrition Research Centre
Newcastle University

Name:

Please complete this diary on the following days:

Day 1


Day 2

Day 3

Thank you

Please leave this section blank.

ID no. Class Diary no.



Day

Date

PLEASE LEAVE THIS SECTION BLANK

CHILD ID: TYPE OF DAY:

SURVEY: DAY OF WEEK:

LUNCH CODE: S/P/H/O

Time	Food or Drink	Amount Eaten	Office use		
			Place of purchase	Code	Weight