National Diet and Nutrition Survey

Years 1 to 9 of the Rolling Programme (2008/2009 – 2016/2017): Time trend and income analyses

A survey carried out on behalf of Public Health England and the Food Standards Agency

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Published January 2019
PHE publications
gateway number: 2018756

PHE supports the UN
Sustainable Development Goals

Authors' acknowledgements

We would like to thank everyone who contributed to the survey and the production of this report. In particular, we would like to thank:

- colleagues at Natcen: Kate Earl, Steve Edwards, Malin Karikoski, Coral Lawson, Dan Philo and Chloe Robinson
- former NatCen colleagues: Vicki Hawkins and Natalie Maplethorpe
- colleagues and former colleagues at UK Medical Research Council (MRC) Elsie Widdowson Laboratory (formerly called MRC Human Nutrition Research): Suzanna Abraham, Birdem Amoutzopoulos, Ruby Baker, Iain Bayes, Veronica Bell, Karen Chamberlain, Darren Cole, Kevin Donkers, Yvette Edwards, Sarah Elsey, Clare Evans, Anila Farooq, Sarah Gibbings, Kate Guberg, Anna Harvey, Matt Harvey, Alison James, Abhilash Krishnankutty, Jonathan Last, Rachael Mack, Tabasum Makhdoomi, Amanda McKillion, Sarah Meadows, Preeti Mistry, Elise Orford, Ann Prentice, Sumantra Ray, Marco Scarbardi, Priya Singh, Edyta Telega, Kirsty Trigg, Michelle Venables, Nicola Wilson, Jenny Winster, Stephen Young
- former MRC EWL colleagues Alison Lennox, the late Les Bluck and late Chris Bates for their involvement in the set up of the Rolling Programme
- colleagues at the MRC Epidemiology Unit, University of Cambridge: Oliver Francis and Stephen Sharp
- colleagues at CDC laboratories for carrying out blood folate analyses
- colleagues at Addenbrooke's Hospital, Cambridge for carrying out blood analyses
- Elaine Gunter (Specimen Solutions, LLC) for an independent quality review of laboratory procedures and analyses
- members of the NDNS Project Board: Julie Lovegrove, Jenny Mindell and Hilary Powers
- the staff at Public Health England, in particular: Louis Levy, Mark Bush, Kate Sweeney, Natasha Powell, Bethany Knowles, Danielle Weiner and Alison Tedstone
- the staff at Food Standards Scotland: Anne Milne and Heather Peace
- the staff at the Food Standards Agency: Robin Clifford, Joseph Shavila and Clifton Gay
- the staff at the Food Standards Agency in Northern Ireland: Naomi Davidson and Joanne Casey
- the staff at the Welsh Government: Sarah Rowles and Chris Roberts
- all the participants who gave up their time to take part in Years 1 to 9 of the NDNS RP

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Executive summary

The National Diet and Nutrition Survey Rolling Programme (NDNS RP) is a continuous cross-sectional survey, designed to assess the diet, nutrient intake and nutritional status of the general population aged 1.5 years and over living in private households in the UK. A representative sample of around 1000 people (500 adults and 500 children) take part in the NDNS RP each year.

The NDNS RP comprises an interview, a 4-day estimated diet diary, physical measurements and a blood and urine sample. Results are used by government to monitor progress toward diet and nutrition objectives of UK Health Departments and to develop policy interventions.

Fieldwork for the first 9 years of the NDNS RP was carried out between 2008/09 and 2016/17.

The foods, nutrients and blood and urine analytes presented in this report were selected for their nutritional and public health relevance to current dietary concerns in the UK. Results are analysed for five age groups: 1.5 to 3 years; 4 to 10 years; 11 to 18 years; 19 to 64 years and 65 years and over, split by sex in all except the youngest age group.

This report includes the following analyses:

- trends over time in relation to food consumption, nutrient intakes and nutritional status in the UK for the first 9 years of the NDNS RP (2008/09-2016/17)
- analysis of food consumption, nutrient intake and nutritional status by equivalised household income[1] for Years 5 to 9 (2012/13 to 2016/17)
- an analysis of seasonal differences in 25-OHD, a marker of vitamin D status, based on data from the first 9 years of the NDNS RP
- descriptive statistics on types and quantities of food consumed for Years 5 to 9

[1] Equivalisation is a standard methodology that adjusts household income to account for different demands on resources, by considering the household size and composition.

Key findings

Trends over time (Years 1 to 9; 2008/09-2016/17)

Foods

There was little change in intake of fruit and vegetables over the 9-year period. All age/sex groups had a mean fruit and vegetable intake below the 5 A Day recommendation over the 9-year period.

There was a downward linear trend in intake of fruit juice over time among consumers in all age/sex groups although there was little change in the proportions drinking it. For children aged 4 to 10 years and 11 to 18 years who consumed fruit juice, there was a decrease in intakes of 54g/day and 50g/day over the 9-year period.

There was little change in intake of oily fish over the 9-year period while intake of red and processed meat showed a downward trend over time.

Over the 9 years, the proportion of children consuming sugar-sweetened soft drinks dropped by 26, 35 and 17 percentage points for those aged 1.5 to 3 years, 4 to 10 years and 11 to 18 years respectively. For those children who drank sugar-sweetened soft drinks, intake also fell significantly over time. For example, sugar-sweetened soft drink intake among consumers aged 11 to 18 years dropped from approximately 285g/day to 185g/day over the 9 years.

Nutrients

Free sugars[2] intake in children significantly decreased over time. As a percentage of total energy, free sugars intake dropped by 2.7, 2.4 and 3.5 percentage points over the 9 years for children aged 1.5 to 3 years, 4 to 10 years and 11 to 18 years respectively.

Adults also showed a reduction in free sugars intake as a percentage of total energy over time, although this was smaller than for children. Despite these decreases, average intakes exceeded the current recommendation of no more than 5% of total energy from free sugars in all age/sex groups over the whole 9 years.

No trend over time was seen in total fat or saturated fatty acid intakes as a percentage of food energy and average intakes exceeded the current recommendation of no more than 11% of food energy from saturated fatty acids over the 9-year period. Adults and

[2] The definition of free sugars includes all added sugars in any form; all sugars naturally present in fruit and vegetable juices, purees and pastes, and similar products in which the structure has been broken down; all sugars in drinks (except for dairy-based drinks) and lactose and galactose added as ingredients, Further details of the methodology for determining free sugars in the NDNS RP are provided in appendix AA.

children showed a significant reduction in *trans* fatty acids intake as a percentage of food energy over time.[3]

There was a small decrease over time in AOAC fibre[4] intake in all child age/sex groups, however this decrease was only significant for children aged 4 to 10 years. Men aged 19 to 64 years showed a significant increase in AOAC fibre intake of 2.4g/day over the 9 years. Average intakes over the 9 years remained well below current recommendations in all age/sex groups.

There was a downward trend in intakes of most vitamins and minerals over the 9-year period for many age/sex groups.

All age/sex groups showed a significant reduction in vitamin A and folate intake over the 9 years. While average folate intake for most age/sex groups remained above the RNI over the 9 years, the average intake for girls aged 11 to 18 years dropped and remained below the RNI. For girls aged 11 to 18 years and women aged 19 to 64 years, the proportion with intakes below the Lower Reference Nutrient Intake (LRNI) increased by 9 and 6 percentage points respectively over the 9-year period.

There was a significant decrease over time in sodium intake[5] in all age/sex groups.

Blood and urinary analytes

Blood folate concentrations decreased significantly over the 9 years for most age/sex groups, and the proportion of participants with folate concentrations indicating risk of anaemia increased. Time-trend analysis of the proportion of women of childbearing age (16 to 49 years) with a red blood cell folate concentration below the threshold for increased risk of neural tube defects-affected pregnancies (748nmol/L), indicates an overall increase from approximately two thirds to almost 90% over the 9 years.

There was little change over the 9 years for markers of status for vitamins B_2 (riboflavin), B_{12}, C and D or in iron, or in lipid profile.

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[3] The levels of *trans* fats produced artificially through food processing have been reduced. The NDNS relies on the availability of food composition data to support estimation of nutrient intakes. This decrease in intake may reflect changes in the composition of foods that took place some time ago, rather than changes in actual nutrient intakes in the survey population over the 9-year period.

[4] AOAC fibre is the term used to describe fibre measured by the American Association of Analytical Chemists (AOAC) methods. AOAC fibre includes resistant starch and lignin in the estimation of total fibre as well as NSP

[5] Sodium intake estimates are based on the sodium content of foods consumed. They do not fully take account of salt added during cooking and exclude salt added at the table by participants.

Equivalised household income[6] (Years 5 to 9; 2012/13-2016/17)

Although those on higher incomes were closer to meeting some recommendations, overall where diets failed to meet recommendations this was the case across the range of income.

Foods

There was evidence of greater intake of fruit and vegetables with increasing income in all age/sex groups except men aged 65 years and over and higher percentages of consumers of fruit juice and oily fish with increasing income.

A downward trend in the percentage consuming sugar-sweetened soft drinks with increasing household income was seen for all age/sex groups except boys aged 11-18 years and adults aged 65 years and over.

Nutrients

Intakes of AOAC fibre, vitamin A, vitamin D and folate significantly increased with increasing income for all or most age/sex groups. Intakes of most other micronutrients also tended to increase with income.

Intake of total fat as a percentage of energy significantly increased with income for adults but significantly decreased with income for children aged 1.5 to 3 years.

Intake of saturated fat tended to increase with increasing income, in contrast to intake of free sugars, which tended to decrease with increasing income. However these changes were small and not significant in all age/sex groups.

Sodium intake[7] significantly increased with increasing income for adults but there was no consistent pattern for children.

Blood analytes

There was an overall trend to better nutritional status, as indicated by concentrations of some biomarkers, with higher income; this was not consistent in all age groups or for all nutrients.

[6] Equivalisation is a standard methodology that adjusts household income to account for different demands on resources, by considering the household size and composition.
[7] Sodium intake estimates are based on the sodium content of foods consumed. They do not fully take account of salt added during cooking and exclude salt added at the table by participants.

Vitamin D status by season (Years 1 to 9; 2008/09-2016/17)

Average 25-hydroxyvitamin D (25-OHD) concentrations were lowest in all age/sex groups during January to March and more than 20nmol/L higher during July to September. During January to March 19% of children aged 4 to 10 years, 37% of children aged 11 to 18 years and 29% of adults had 25-OHD below 25nmol/L, the threshold indicating risk of deficiency.

Chapter 1 Background and purpose

1.1 Background

The National Diet and Nutrition Survey Rolling Programme (NDNS RP) is a cross-sectional survey with a continuous programme of fieldwork, designed to assess the diet, nutrient intake and nutritional status of the general population aged 1.5 years and over living in private households in the UK. The core NDNS RP is jointly funded by Public Health England (PHE)[8] and the UK Food Standards Agency (FSA). The NDNS RP is carried out by a consortium comprising NatCen Social Research (NatCen) and the Medical Research Council Elsie Widdowson Laboratory (MRC EWL)[9,10] with fieldwork in Northern Ireland carried out by the Northern Ireland Statistics and Research Agency (NISRA).[11]

The NDNS provides the only source of nationally representative UK data on the types and quantities of foods consumed by individuals, from which estimates of nutrient intake for the population are derived.[i] Results are used by Government to monitor progress toward diet and nutrition objectives of UK Health Departments and develop policy interventions, for example work to monitor progress towards a healthy, balanced diet as visually depicted in the Eatwell Guide.[ii] The NDNS is an important source of evidence underpinning the Scientific Advisory Committee on Nutrition's (SACN) work relating to national nutrition policy. The food consumption data is also used by the FSA to assess exposure to chemicals in food, as part of the risk assessment and communication process in response to a food emergency or to inform negotiations on setting regulatory limits for contaminants.

The NDNS programme began in 1992 as a series of cross-sectional surveys designed to be representative of the UK population, each covering a different age group: pre-school children (aged 1.5 to 4.5 years);[iii] young people (aged 4 to 18 years);[iv] adults (aged 19 to 64 years)[v] and older adults (aged 65 years and over).[vi] Since 2008, the NDNS has run continuously as a rolling programme (RP) covering adults and children aged 1.5 years and over. Methods used in the NDNS are kept under review to ensure they remain the best practical methods available.

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[8] From 1 April 2013, responsibility for the NDNS contract transferred from the Department of Health in England to the Department of Health's Executive Agency, Public Health England (PHE).
[9] In 2016, following restructuring and refocusing of its research interests MRC Human Nutrition Research was renamed the MRC Elsie Widdowson Laboratory (MRC EWL). This took effect from 01 September 2016.
[10] The MRC EWL Unit closed on 20 December 2018. Work on the current NDNS contracts (up to and including Year 14) continues, led by NatCen Social Research working with the MRC Epidemiology Unit, University of Cambridge.
[11] In Years 1 to 5 the consortium also included the University College London Medical School (UCL).

1.2 Content of this report

This report includes the following analyses:

- trends over time in relation to food consumption, nutrient intakes and nutritional status in the UK for the first 9 years of the NDNS RP (2008/09-2016/17)
- analysis of food consumption, nutrient intake and nutritional status by equivalised household income[12] for Years 5 to 9 (2012/13 to 2016/17)
- an analysis of seasonal differences in 25-OHD, a marker of vitamin D status, based on data from the first 9 years of the NDNS RP
- descriptive statistics on types and quantities of food consumed for Years 5 to 9

The NDNS RP sample is drawn from all four UK countries, and is designed to be nationally representative. Recruitment in both Wales[13] and Northern Ireland[14] was boosted in most years in order to achieve country-specific, representative dietary health data.[15] Separate Years 1 to 9 reports for Wales and for Northern Ireland will be published in 2019 (see section 1.7).

Background information on the survey, including the sample and methodology, is provided in chapter 2 and further details can be found in the appendices A to AA.

The time trend and equivalised household income[16] analyses in this report have been conducted on a number of key foods, nutrients, and blood and urinary analytes, selected for their nutritional and public health relevance to current dietary concerns in the UK. Plots and tables are provided in Excel and commentary is provided in chapters 2-7.

1.3 Interpreting the time trend and income analysis

In this report the time trend and equivalised income[16] analyses have been presented as plots in Excel and the following guidance is provided to aid interpretation of these plots. Appendix U provides a full explanation of the analytical approach.

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[12] Equivalisation is a standard methodology that adjusts household income to account for different demands on resources, by considering the household size and composition.
[13] The Wales boost was funded by the Food Standards Agency (FSA) in Wales which previously shared policy responsibility for diet and nutrition of the population in Wales. This policy area is now solely the responsibility of the Welsh Government.
[14] The Northern Ireland boost has been co-funded by three funding partners: the Department of Health,); the Food Safety Promotion Board (safefood) and FSA in NI. FSA in NI has responsibility for monitoring the diet of the population in Northern Ireland.
[15] Additional recruitment was undertaken in Wales (Years 2 to 9) and in Northern Ireland (Years 1 to 4 and Years 6 to 9) in order to achieve representative data for each country and to enable comparisons to be made with UK results. Country boosts were also funded in Scotland in Years 1 to 4.
[16] Equivalisation is a standard methodology that adjusts household income to account for different demands on resources, by considering the household size and composition.

In each case the analysis has been summarised using the slope of the regression line along with the 95% confidence interval. Where there is a statistically significant trend ($p<0.05$) the quantification of the slope has been assigned an asterisk. The slope of the regression line represents the average change per year (trend analysis) or per £10,000 (income analysis).

Where a data distribution was highly skewed it was analysed on a log scale. In these cases the geometric mean is the most appropriate average and changes are represented as ratios of geometric means (rather than differences of arithmetic means as they were for non-logged analyses). The average per year (trend analysis) or per £10,000 (income analysis) ratio of geometric means has been converted into a per cent change per year or per £10,000.

Information has been provided in appendix U of this report regarding how the average increase/reduction over the 9 years of the survey was calculated for the time trend analysis. It should be noted that the calculation method for variables that are analysed on the log scale is different from that for variables analysed on the linear scale. Nine-year change values are presented in Excel tables U.1-U.4.

Due to differences in the variation of the datapoints or sample size within each of the age/sex groups, there are instances for some foods/nutrients/blood analytes where larger slopes were not statistically significant whereas smaller slopes were statistically significant.

For foods where there were a large number of non-consumers, percentage of consumers and intakes for consumers only are presented instead of population intakes. This is because the regression analysis of population intakes is highly influenced by zero values which can be misleading.

1.4 Methodological changes during Years 1 to 9 of the NDNS RP

The data collection and analysis methods used in the first 9 years of the NDNS RP (2008/09-2016/17) were kept as consistent as possible over time. Dietary data was collected through a 4-day food and drink diary throughout the 9 years. Blood sampling, processing and analysis methods were generally unchanged, but, where changes were needed, crossover studies were carried out to ensure comparability of results over time was maintained. Details of the dietary data and blood and urine sample collection, processing and analyses along with any key methodological considerations/changes that occurred during Years 1 to 9 are provided in appendices A and Q of this report respectively.

1.5 Methodological considerations

The misreporting of energy intake (EI) is known to be an issue for all dietary surveys and studies.[vii,viii] Previous NDNS and the current NDNS RP are unique amongst large-scale population surveys in their inclusion of doubly labelled water (DLW)[17] as an objective biomarker to validate EI estimated from reported food consumption. In the NDNS RP, estimates of EI from the 4-day diary were compared with measurements of total energy expenditure (TEE) using the DLW technique in 2 separate sub-samples of survey participants. The first sub-sample was taken from Year 1 (2008/09) and Year 3 (2010/11) and the second sub-sample from Year 6 (2013/14) and Year 7 (2014/15). The results of analysis of the most recent DLW sub-study indicated that reported EI in children aged 4 to 10 years was on average 13% lower than TEE measured by the DLW technique, 31% lower in children aged 11 to 15 years, 33% lower in adults aged 16 to 64 years and 28% lower in adults aged 65 years and over. These results are consistent with findings from the DLW sub-sample taken from Years 1 and 3 which were reported in appendix X of the UK Years 1 to 4 report.[ix]

The energy and nutrient intakes presented in this report have not been adjusted to take account of underreporting.

Appendix X of this report provides a summary of the DLW method, the results of the UK analysis and an illustration of a number of considerations relevant to the interpretation of the survey findings. Appendix X of the UK Years 1 to 4 report[ix] provides the results of the UK analysis for the DLW sub-study carried out in Years 1 and 3.

1.6 Changes to UK dietary recommendations

Government advice on energy and nutrient intakes is based on recommendations from the Committee on Medical Aspects of Food and Nutrition Policy (COMA) and its successor, the Scientific Advisory Committee on Nutrition (SACN).[18] Since the start of the NDNS RP in 2008 government has revised its advice on energy intakes, red and processed meat consumption, and intakes of sugars, fibre and vitamin D, as a result of changes to recommendations from SACN. Revised advice has also been issued on

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[17] The doubly labelled water (DLW) technique is widely agreed to be the most accurate way of assessing energy expenditure (EE) over 1 to 2 weeks. Participants in DLW studies drink a weighed amount of water labelled with known amounts of the stable isotopes of hydrogen (^{2}H) and oxygen ($^{18}O_2$) based on their body weight. Loss of the two isotopes from body water is assessed by measurement of the rate of decline in concentration of the isotope in samples of the subject's urine, collected during the study period, and measured by isotope ratio mass spectrometry. The difference between the elimination rates of the two isotopes reflects the rate at which CO_2 is produced from metabolism. EE can then be estimated from the CO_2 production.

[18] The Scientific Advisory Committee on Nutrition (SACN) was established in 2000 following the disbandment of COMA in March 2000.

consumption of fruit juice and smoothies in the context of government 5 A Day recommendations.

In 2011 SACN undertook a review of the evidence for energy requirements and made revised recommendations for energy intake.[x] The revised recommendations for most age/sex groups (except for infants and young childen) were higher than those originally set by COMA in 1991. Government decided to cap recommendations at 10.5MJ (2500kcal)/day for males and 8.4MJ (2000kcal)/day for females to help address issues of overweight and obesity.[ii] In the same year SACN also published its review of iron and health[xi] which included a consideration of the evidence for red and processed meat consumption and colorectal cancer risk. SACN recommended that adults with high intakes of red and processed meat (around 90g/day or more) should consider reducing their intakes towards the UK average of around 70g/day. A mean intake of 70g/day is used as the threshold for monitoring purposes.

In 2015, the definition and dietary recommendations for sugars and fibre were revised by SACN.[xii] SACN recommended that a definition of free sugars should be adopted in the UK replacing the term non-milk extrinsic sugars (NMES) on which sugar intake recommendations had been based for the previous 25 years. SACN recommended that free sugars intake should not exceed 5% of total energy intake for adults and children over 2 years. As the definitions of free sugars[xiii] and NMES are broadly similar this effectively represented a halving of the original recommendation of 10% of total energy from NMES. The definition of dietary fibre also changed from non-starch polysaccharide (NSP) to AOAC fibre which includes starch and lignin in the estimation of total fibre as well as NSP. The new recommendation for AOAC fibre intake is 30g/day for adults, which represents an increase over the previous recommendation of 18g NSP per day (equivalent to 23-24g AOAC fibre).

In 2016 SACN published an evidence review of vitamin D and health and set a Reference Nutrient Intake (RNI) of 10µg/day for adults and children of all ages,[19,xiv] replacing previous advice that the RNI was required only for children under 4 years and older adults aged 65 years and over. Government advice was updated to recommend that in the summer months the majority of adults and children aged 5 years and older will probably obtain sufficient vitamin D from sunshine when they are outdoors, and by following a healthy, balanced diet as shown in the Eatwell Guide. Because it is difficult to get enough vitamin D from food, everyone over the age of 5 years should consider taking a daily supplement containing 10µg vitamin D during the autumn and winter months.

[19] The Scientific Advisory Committee on Nutrition (SACN) vitamin D and health report published in 2016 recommended an RNI of 10µg/day for those aged 4 years and over and a safe intake of 10µg/day for those aged 1 to 4 years.

People who have no or very little sunshine exposure such as those who are frail or housebound or are in an institution such as a care home so are not often outdoors, and those who usually wear clothes that cover up most of their skin when outdoors, should take a daily supplement containing 10µg vitamin D throughout the year. People from minority ethnic groups with dark skin, such as those of African, African-Caribbean or South Asian origin, might not get enough vitamin D from sunlight, so should consider taking a vitamin D supplement throughout the year. Children aged from one to four years should be given a daily supplement containing 10µg vitamin D throughout the year. Infants from birth to one year of age should also be given a daily supplement containing 8.5-10µg vitamin D unless they are receiving at least 500ml of infant formula per day.

Over the period of the NDNS RP, the 5 A Day recommendation[xv] for fruit and vegetables has changed in relation to advice on smoothies. Before 2016 smoothies containing pureed fruit could count towards 5 A Day in addition to fruit juice. The recommendation since 2016 is that smoothies should be treated the same as fruit juice and 150ml of fruit juice or smoothies combined count as one of your 5 A Day; any additional fruit juice or smoothies above this does not count. The calculation of 5 A Day in the NDNS RP was changed accordingly for Year 9.

1.7 Previous NDNS RP reports

This report builds on a series of previous NDNS RP reports that have been published since Year 1 (2008/09). These include the Years 1 to 4 combined reports for the UK,[ix] Scotland (only)[xvi] and Northern Ireland (only),[xvii] the Wales Years 2 to 5 combined report[xviii] and a series of paired years results reports commencing from Year 5, ie, Years 5 and 6 (2012/13-2013/14)[xix] and Years 7 and 8 (2014/15-2015/16),[xx] along with a supplementary folate report for Years 1 to 4 combined published in 2017.[xxi] The NDNS also includes a series of urinary sodium surveys for the assessment of population salt intake, with fieldwork in England in 2011[xxii] and 2014,[xxiii] Scotland in 2014[xxiv] and Northern Ireland in 2015.[xxv]

1.8 Future reports

Reports of the latest data for Northern Ireland and Wales are due to be published in 2019. Both reports will cover Years 1 to 9 (combined) (2008/09-2016/17) and will include, respectively, an analysis of changes in the Northern Ireland and Wales diet and nutrient intake both over time (Years 1 to 9 (2008/09-2016/17)) and by equivalised income[20] (Years 5 to 9 (2012/13-2016/17)), including comparisons to the UK for the same time period. The reports will also include descriptive statistics on food consumption, nutrient

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[20] Equivalisation is a standard methodology that adjusts household income to account for different demands on resources, by considering the household size and composition.

intakes and blood analytes for Northern Ireland and Wales (respectively) for Years 5 to 9 combined.

Data for Years 1 to 9 are deposited at the UK Data Service. Data are deposited routinely after each NDNS RP report publication.[xxvi]

Chapter 2 Characteristics and representativeness of the NDNS RP sample (Years 5 to 9 combined; 2012/13-2016/17)

2.1 Introduction

This chapter includes information about response rates for Years 5 to 9 (combined);[21,ix] differences between individual years are shown in the text. Commentary is also provided on the socio-demographic characteristics of the NDNS RP sample (split by age/sex), including representativeness to the UK population shown via mid-year population estimates.[22,xxvii] Also shown are anthropometric measurements, using data collected during the interviewer and nurse visits. Information regarding weighting the survey data is also discussed in this chapter. Detailed information about the sampling and weighting methodology is provided in appendix B.

2.2 Response rates

2.2.1 Household level response

Overall, of the 21,646 addresses issued to interviewers for Years 5 to 9 (combined), 45% were eligible for household selection. Ineligible addresses included vacant or derelict properties and institutions. Addresses that were selected for the child boost and were screened out because they did not contain any children in the eligible age range were also included in the ineligible category.

Household selection was carried out at 88% of eligible addresses. The individuals in the remaining 12% of addresses refused to participate before the household selection could be carried out.

Ref: Table 2.1

2.2.2 Individual level response

The overall response rate for fully productive individuals (ie, those completing 3 or 4 diary recording days) was 54% in Year 5, 53% in Year 6, 55% in Year 7, 49% in Year 8 and 50% in Year 9, giving a sample size of 6,522 fully productive individuals. Of the

[21] Equivalent information for the earlier years is provided in the Years 1 to 4 (combined) report.
[22] Annual population estimates for the UK and its constituent countries are produced by the Office for National Statistics.

6,522 fully productive individuals, 6385 (98%) completed the diet diary for 4 days and 137 (2%) completed 3 days. Analyses in this report (including response rates for subsequent stages/components of the survey) are based on these 6,522 individuals.

In Years 6 to 9, participants aged 4 years and over were asked to provide a spot urine sample. 80% of these fully productive participants provided a spot urine sample (82% of adults, 77% of children).

Seventy-four per cent of all fully productive participants (Years 5 to 9) were visited by a nurse.[23]

Fifty-two per cent of fully productive adults and 26% of fully productive children provided a blood sample. Younger children were less likely to give a blood sample than older children or adults: 14% of those aged 1.5 to 3 years and 23% of those aged 4 to 10 years provided a blood sample compared with 34% of those aged 11 to 18 years and 52% of those aged 19 years and over. Ref: Table 2.2

2.3 Characteristics of the NDNS RP sample

2.3.1 Sex

In the unweighted NDNS RP sample, 40.8% of adults aged 19 years and over were men and 59.2% were women, while for children (aged 1.5 to 18 years) 51.6% were boys and 48.4% were girls. The sample was weighted to reflect the distribution of males and females in the UK population.[24]

After weighting, 48.6% of the adult sample were male and 51.4% were female; 51.2% of the child sample were boys and 48.8% were girls. Ref: Table 2.3

2.3.2 Age

In the overall unweighted NDNS RP sample, 51.4% were adults aged 19 and over (38.7% aged 19 to 64 years and 12.7% aged 65 years and over) and the remaining 48.6% were children and young people aged 1.5 to 18 years.

The sample was weighted to bring the age profile of the sample in line with the age profile of men and women in the UK population. Once weighted, 79.1% of the sample

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[23] The remainder of fully productive respondents either refused to progress to stage 2 or, in a small number of cases, could not be visited during the nurse fieldwork period.
[24] Annual population estimates for the UK and its constituent countries are produced by the Office for National Statistics.

were adults (61.1% aged 19 to 64 years and 17.9% aged 65 years and over) and 20.9% were children and young people. Ref: Table 2.4

All text and tables in the remainder of this chapter use weighted data to present a representative age/sex profile of the UK population.

2.3.3 Ethnicity

In terms of ethnicity, 86.3% of the overall sample (adults and children) were White British, 7.3% were Asian/Asian British, 2.9% Black/Black British, 1.7% Mixed and 1.8% other ethnicity; this is broadly in line with the UK population.[xxviii] Ref: Table 2.5

2.3.4 National Statistics Socio-Economic Classification (NS-SEC)

Participants were assigned a socio-economic classification[25,xxix] based on the current or most recent job of the Household Reference Person (HRP) for their household.[26,27]

Amongst the adult sample, the HRP was most likely to be in lower managerial and professional occupations (23.7%), higher managerial and professional occupations (19.5%) or semi-routine occupations (12.5%). A further 2.9% of the adult sample were in a household where the HRP had never worked. A similar pattern was seen across the child sample. Findings are broadly in line with the UK population.[xxviii] Ref: Table 2.6

2.4 Anthropometric measures

2.4.1 Introduction

A number of anthropometric measures were taken to provide contextual information on body weight and abdominal obesity. Detailed descriptions of the measurement protocols used in the NDNS RP are available in appendix L but a brief description is provided within each section below.

Height and weight measurements, from which body mass index (BMI) was calculated, were taken during the interviewer visits. Height and weight were measured using a portable stadiometer, measuring to the nearest 0.1 cm (and if between two mm, rounded to the nearest even mm) and weighing scales, measuring to the nearest 0.1kg. BMI = weight (kg) / height squared (m^2) was calculated by the interviewer's Computer

[25] NS-SEC was constructed to measure the employment relations and conditions of occupations. It has been available since 2001 for use in all official statistics and surveys.
[26] The 'Household Reference Person' (HRP) was defined as the householder (a person in whose name the property is owned or rented) with the highest income. If there was more than one householder and they had equal income, then the eldest was selected as the HRP.
[27] Some households contained both an adult and a child participant. Such households and their HRP will be represented in both the adult and child figures.

Assisted Personal Interview (CAPI) programme. For participants whose height could not be measured, estimated height based on demispan[28,xxx] was used to calculate BMI.[29,xxxi]

For children aged 1.5 to 2 years, the interviewer measured length instead of height and this measurement was used in place of height when calculating BMI.[30]

Waist and hip circumference[31] was measured for all consenting participants aged 11 years and over during the nurse visit. These measurements allow calculation of waist:hip ratio, which provide an indication of abdominal obesity. Waist and hip circumferences were measured using an insertion tape measure.

2.4.2 Obesity in adults

BMI status has been categorised according to the classification used by the World Health Organization (WHO)[xxxii] and the National Institute for Health and Clinical Excellence (NICE),[xxxiii] as shown in table 2A below:

Table 2A: BMI classification

BMI (kg/m2)	**Description**
Less than 18.5	Underweight
18.5 to less than 25	Normal
25 to less than 30	Overweight, not obese
30 or more	Obese, including morbidly[32]
40 or more	Morbidly obese[33]

Mean BMI was similar for men and women (27.4 and 27.2 respectively). However, a greater proportion of men (43.7%) were overweight than women (32.7%) and were similarly more likely to be overweight including obese than women (67.9% of men were overweight, obese or morbidly obese compared with 58.9% of women).

[28] Demispan is defined as the distance between the mid-point of the sternal notch and the finger roots with the arm outstretched laterally. Using BMI based on demispan equivalent height is recommended where no measured height is available, and has been suggested as a preferred measure of BMI in older people.
[29] The demispan equivalent height was calculated using regression equations derived by Bassey. Females: Height (cm) = (1.35x demispan in cm) + 60.1. Males: Height in (cm) = (1.40x demispan in cm) + 57.8.
[30] These data are not shown but are included in the archived data.
[31] All fieldworkers were trained to carefully observe the standard measurement protocols. Each measurement was taken twice. Where the discrepancy between the measurements was at or above a given value (height ≥ 0.5cm, weight ≥ 0.2kg, waist and hip circumferences ≥ 3cm), a third measurement was taken. The mean of the 2 closest measurements was used. If only one measurement was available, it was excluded from the analysis.
[32] 'Obese' includes Obese class I, Obese class II and Obese class III from the World Health Organization's body mass index (BMI) classification.
[33] 'Morbidly obese' includes Obese class III from the World Health Organization's body mass index (BMI) classification.

Table 2.7a shows mean BMI and BMI status, in adults, by age group and sex. An adult was classified as having abdominal obesity if their waist circumference was raised (greater than 102cm for men and greater than 88cm for women), or if their waist: hip ratio was raised (greater than 0.95 for men and greater than 0.85 for women).[xxxiv]

Mean waist circumference was higher in men than in women (mean waist circumference was 97.5cm in men and 88.0cm in women). However, a significantly greater proportion of women had a raised waist circumference than men (46.8% of women, compared with 34.6% of men).

Waist circumference increased with age. For both men and women, mean waist circumference and the proportion with a raised waist circumference was higher amongst older adults (aged 65 years and over) than those aged 16 to 64 years.

Mean waist:hip ratio was 0.9 amongst men and 0.8 amongst women. The proportion with a raised waist:hip ratio increased significantly with age: 35.3% of men aged 19 to 64 years had a raised waist:hip ratio, and that increased to 62.2% amongst men aged 65 years and over. Amongst women, 35.2% of those aged 19 to 64 years had a raised waist:hip ratio and that increased to 63.9% amongst women aged 65 years and over.

Ref: Table 2.7a

2.4.3 Obesity in children

New UK WHO growth charts for children from birth to 4 years were introduced for all new births in England, Wales and Northern Ireland from May 2009 and in Scotland from January 2010.[xxxv] These are based on WHO Growth Standards from data in infants who were exclusively or predominantly breastfed.[xxxvi,34]

Growth standards for the youngest children (aged 0 to 4 years) are based on breastfed babies, who tend to have a different pattern of growth compared with formula-fed infants, whereas growth standards for older children are based on the growth of UK children regardless of feeding (UK 1990 reference values). Differences between the youngest and oldest children should be viewed with caution due to the use of different growth standards.

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[34] The new UK-WHO 0-4 years growth charts were introduced in the UK because they represent an international standard of growth for healthy infants and young children. Breastfed infants exhibit a healthier pattern of growth. The new charts were constructed using the WHO Growth Standards for infants aged 2 weeks to 4 years, which used data from healthy children from around the world with no known health or environmental constraints to growth. WHO found that infants worldwide have very similar patterns of linear growth, whatever their ethnic origin. The new charts provide a description of optimal growth, describing the ideal patterns of growth for all UK children, whatever their ethnic origin and however they are fed in infancy. The WHO data is combined with birth data for gestations 23 to 42 weeks from the UK1990 growth reference, as the WHO dataset did not include preterm infants. The UK1990 reference is still to be used for children aged 4 years and over.

For clinical purposes, the UK growth charts define overweight as above the 91st but on or below the 98th centile for BMI and obesity as above the 98th centile. However, this report uses the 85th and 95th centiles to define overweight and obesity, as is standard UK government practice for population monitoring.[xxxvii]

Similar proportions of boys and girls were overweight (13.5% and 14.1% respectively). However, a greater proportion of boys (19.4%) were obese, compared with girls (15.1%).

There was no clear pattern of BMI among children by age. Ref: Table 2.7b

Chapter 3 Time trend analysis (Years 1 to 9; 2008/09- 2016/17) for selected foods and nutrients

3.1 Introduction

This chapter presents time trend analyses for selected key foods and nutrients over the 9-year period 2008/09-2016/17 (fieldwork years 1 to 9) of the NDNS RP. The foods and nutrients reported here were selected for their nutritional and public health relevance to current dietary concerns in the UK.

The time trend analysis uses a linear regression model, which splits each survey year into quarters to characterise more fully the trends over time and to provide an estimate of the average per year change over the 9-year period. The slope of the regression line represents the average year-by-year change. The analysis is shown as a plot in Excel. Refer to chapter 1 for a guide to interpretation of the time trend analysis plots (see section 1.3). To calculate the 9-year change refer to appendix U, which provides instructions on how to scale-up the cumulative change and explains that the calculations for variables that are analysed on the log scale are different from those for variables analysed on the linear scale. Nine-year change values are presented in Excel tables U.1-U.4.

Many of the trends identified by the analysis were small in magnitude and some were not statistically significant. The commentary in this chapter describes trends in key foods and nutrients taking account of statistical significance (as indicated by the confidence intervals set out in brackets in the text) and whether the change is nutritionally meaningful. The text describes upward or downward trends and the overall size of any observed changes in intakes.[35] The plots provide an indication of mean food and/or nutrient intakes across the 9-year period; however this report does not provide or describe the group mean values for each year. These can be found for paired years from Years 1 to 8 in the Years 7 and 8 (combined) report.[xx] No commentary is provided in those cases where a regression line cannot be fitted; this was either because most of the data are zero or because there is a clear non-linear relationship.

[35] The 95% Confidence Intervals (CIs) presented in the plots relate to the magnitude and direction of change ie, negative CIs for a downward trend. In the text, downward trends are expressed as a decrease and so the CIs quoted represent the magnitude of the decrease not the direction of change.

Trends in arithmetic mean are reported as 'change per year' where the data were normally distributed and could be analysed without transformation. Where the data were skewed and needed to be log-transformed before analysis, the trends in geometric mean are reported as 'percentage change per year' (see section 1.3 of chapter 1 for more detail).

3.2 Foods

3.2.1 Population intake

For total fruit and vegetables, total meat, and red and processed meat, and for 5 A Day fruit and vegetable portions, the proportion of non-consumers over the 4-day period was low. Therefore, the trends in population intakes for the whole sample (including non-consumers) are presented.

Fruit and Vegetables. There was little change observed over the 9-year period (2008/09 to 2016/17) for total fruit and vegetable intake in most age/sex groups. An average yearly increase in total fruit and vegetable intake of 5g/day (CI 1, 9) was seen in men aged 19 to 64 years. The majority of this increase was attributable to an average yearly increase in vegetable intake of 4g/day (CI 1, 7).

5 A Day. The number of 5 A Day portions consumed are presented for the age groups for which there is a government recommendation,[xxxviii] that is for 11 to 18 years, 19 to 64 years and 65 years and over. Changes over the 9-year period were very small or close to zero for these age/sex groups for average number of 5 A Day portions consumed. Changes were also very small for the proportion meeting the 5 A Day recommendation. As indicated by the regression line, all age/sex groups had a mean fruit and vegetable intake below the 5 A Day recommendation.[xxxviii]

Total meat. Little change was observed in the intake of total meat over the 9-year period.

Total red and processed meat. All age/sex groups showed a downward trend over the 9-year period in intake of red and processed meat, although this was not always statistically significant. The largest yearly reduction was seen in boys aged 11 to 18 years (3g/day, CI 2, 4). The percentage of consumers of red and processed meat decreased for children aged 11 to 18 years and most adult age/sex groups by around 1 percentage point per year. The previous NDNS RP report showed that men aged 19 to 64 years and men aged 65 years and over had a mean total red and processed meat intake above the recommended 70g per day.[36,xx,xxxix] Ref: Table 3.1-3.5 & 3.8-3.10

[36] The Department of Health has advised that people who eat a lot of red and processed meat a day (more than 90g cooked weight) cut down to 70g.

3.2.2 Percentage of consumers and intake by consumers only

For fruit juice, white meat, total fish (and oily fish) and sugar-sweetened soft drinks, trends are presented for percentage of consumers and intakes for consumers only because the proportion of non-consumers over the 4 days was high, or was high in some age/sex groups, and the inclusion of non-consumers can cause the regression analysis of population intakes to be misleading (see section 1.3 of chapter 1).

Fruit juice. There was little change observed in the percentage consuming fruit juice[37] in most age/sex groups over the 9-year period (2008/09 to 2016/17). The largest change was in boys aged 4 to 10 years who showed an average yearly reduction in the percentage consuming fruit juice of 2 percentage points (CI 0, 3). Intakes of fruit juice (consumers only) decreased over time in all age/sex groups. The average yearly reduction was statistically significant for children aged 4 to 10 years (6g/day, CI 4, 8), girls aged 11 to 18 years (5g/day, CI:1, 10) and women aged 19 to 64 years (4g/day, CI 1, 6). This is equivalent to a reduction of 54g/day, 48g/day and 32g/day respectively over the 9 years.

White meat. Little change was observed over the 9 years in terms of the percentage consuming white meat or in the intake of white meat by consumers.

Total fish. There was little change in most age/sex groups in the percentage consuming fish over the 9-year period and those changes seen were not in a consistent direction. The largest statistically significant changes were observed in girls aged 4 to 10 years and in boys aged 11 to 18 years, with an average yearly increase in the percentage of consumers of 2 percentage points (CI 0, 3 and 1, 3 respectively). Changes over time in fish intake by consumers were very small or close to zero for all age/sex groups.

Oily fish. There was a statistically significant 1 percentage point (CI 1, 2) increase per year in the percentage of consumers of oily fish over time for children aged 11 to 18 years. A 1 percentage point increase was also seen for men aged 19 to 64 years and adults aged 65 years and over, although these changes were not statistically significant. For consumers of oily fish, changes in intake were small and there was no consistent pattern in the direction of change.

Sugar-sweetened soft drinks – children. There was a significant downward trend in the percentage of children consuming sugar-sweetened soft drinks. In children aged 1.5 to 3 years, 4 to 10 years and 11 to 18 years there was an average reduction in the percentage consuming sugar-sweetened soft drinks per year of 3 (CI 2, 4), 4 (CI 3, 5) and 2 (CI 1, 3) percentage points respectively. This is equivalent to a reduction of 26, 35 and 17 percentage points over the 9 years. Data for intake of sugar-sweetened soft drinks (consumers only) were skewed and were log-transformed before analysis. The

[37] This includes the fruit juice component of smoothies but not smoothie fruit.

trends in geometric mean are reported as an average percentage change per year. Consumption of sugar-sweetened soft drinks among children (consumers only) showed an average yearly reduction of 6% (CI 1, 10), 3% (CI 1, 5) and 5% (CI 3, 7) for each age group respectively.

Sugar-sweetened soft drinks – adults. In adults aged 19 to 64 years an average reduction in the percentage consuming sugar-sweetened soft drinks of 1 percentage point per year (CI 1, 2) was observed. There was no significant reduction in adults aged 65 years and over. A downward trend in intake of sugar-sweetened soft drinks was observed in adults aged 65 years and over (consumers only) but not in those aged 19 to 64 years. Women aged 65 years and over who drank sugar-sweetened soft drinks showed an average reduction in consumption of 5% per year (CI 1, 9).

Ref: Table 3.6-3.7, 3.11-3.18

3.3 Energy and macronutrients

To put the trends for energy and macronutrients over time into nutritional context, reference is made to population dietary intake in terms of Dietary Reference Values (DRVs).[xi,xii] Where relevant, DRVs are presented in the individual plots and are referred to as ‘recommendations’ in the rest of this section.The recommendations for macronutrients generally indicate the maximum contribution the nutrient should make to energy intake at the population level or, in the case of AOAC fibre, represent the recommended population average intake.

Total energy. There was an average decrease in total energy intakes for all age/sex groups over the 9-year period, although this was not always statistically significant. The largest changes were seen for girls aged 4 to 10 years and boys aged 11 to 18 years with an average yearly reduction in total energy intake of 0.10MJ/day (24kcal) (CI 0.07, 0.13) and 0.12MJ/day (29kcal) (CI 0.07, 0.18) respectively. For other age/sex groups the yearly decreases were less than 0.05MJ/day. The same pattern was seen for food energy[38] intake (ie, excluding energy from alcohol) for all age/sex groups.

Total fat. There was no consistent pattern in direction of change in total fat intake as a percentage of food energy across the age/sex groups over time, and overall the changes were very small or close to zero. The previous NDNS RP report has shown that mean intake in all age/sex groups met or was close to meeting the recommendation of no more than 35% food energy from total fat.[xx]

Saturated fatty acids. Over the 9-year period, changes in saturated fatty acids intake as a percentage of food energy were very small or close to zero across the age/sex groups. As indicated by the regression line, mean saturated fatty acids intake exceeded

[38] Food energy intake excludes energy from alcohol.

the recommendation of no more than 11% food energy in all age/sex groups over the 9-year period.

***Trans* fatty acids**. There was a statistically significant average reduction per year in trans fatty acids intake as a percentage of food energy in all age/sex groups.[39] The regression line indicates that all age/sex groups met the recommendation of no more than 2% food energy from *trans* fatty acids over the 9-year period.

Free sugars.[40] The largest changes in free sugars intake as a percentage of total energy over the 9-year period were seen in children. Children aged 1.5 to 3 years, 4 to 10 years and 11 to 18 years had an average yearly reduction of 0.3 (CI 0.2, 0.4), 0.3 (CI 0.2, 0.4) and 0.4 (CI 0.3, 0.5) percentage points respectively. This is equivalent to a reduction of 2.7, 2.4 and 3.5 percentage points over the 9 years. With the exception of men aged 65 years and over, reductions were also observed over time for adults, however, these reductions were smaller than for children and were not statistically significant in all groups. As indicated by the regression line, mean free sugars intake exceeded the current recommendation of no more than 5% total energy in all age/sex groups.[41]

AOAC fibre.[42] AOAC fibre intake in children showed a small but consistent decrease over the 9-year period, this was statistically significant for girls aged 4 to 10 years (0.2g/day per year, CI 0.1, 0.3). In contrast, there was a significant average increase in AOAC fibre intake of 0.3g/day per year (CI 0.0, 0.5) for men aged 19 to 64 years. For the other adult age/sex groups, the changes were small or close to zero. The previous NDNS RP report has shown that mean AOAC fibre intake in all age/sex groups was below current recommendations.[xx,43]

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[39] The downward trend in intake may reflect changes in the composition of foods rather than changes in actual nutrient intakes in the survey population over the 9-year period. The NDNS Nutrient Databank (NDB) provides food composition data to support the estimation of nutrient intakes in the NDNS RP. Each survey year is analysed using a different version of the NDB which is updated so that it best reflects the nutrient content of foods in that year. Updates aim to capture new food products to reflect foods available at the time of fieldwork data collection and to reflect reformulation of products (such as reductions in fat, sugar or salt content). It is important to note that changes in the NDB are partly driven by the availability of new analytical data. New analytical data for *trans* fatty acids in processed foods was incorporated into the NDB in Year 3 (2010/11) although the levels of *trans* fatty acids in these foods had already been reduced prior to this.

[40] The definition of free sugars includes all added sugars in any form; all sugars naturally present in fruit and vegetable juices, purees and pastes, and similar products in which the structure has been broken down; all sugars in drinks (except for dairy-based drinks); and lactose and galactose added as ingredients. Further details of the methodology for determining free sugars in the NDNS RP are provided in appendix AA.

[41] The Scientific Advisory Committee on Nutrition (SACN) recommendation that free sugars provides no more than 5% of daily total energy intake for those aged 2 years and over.

[42] AOAC fibre is the term used to describe fibre measured by the American Association of Analytical Chemists (AOAC) methods. AOAC fibre includes resistant starch and lignin in the estimation of total fibre as well as non-starch polysaccharides.

[43] The Scientific Advisory Committee on Nutrition (SACN) AOAC fibre recommendations: 30g/day for adults; 25g/day for older children aged 11-16 years; 20g/day for the 5-11 year age group; 15g/day for the 2-5 year age group.

Alcohol. There was a downward trend over time in the percentage consuming alcohol for all age/sex groups from 11 years upwards, and this was statistically significant for adults aged 19 to 64 years (2 percentage points, CI 1, 2) and for girls aged 11 to 18 years (1 percentage point, CI 0,2). For those who consumed alcohol there was little change over time in alcohol intake as a percentage of total energy. The exception was the 11 to 18 years age group where there was an average yearly decrease of 0.3 percentage points (CI 0.0, 0.5).

Protein and carbohydrate. For protein and carbohydrate intake as a percentage of food energy, the changes over time were very small or close to zero. Ref: Table 3.19-3.29

3.4 Micronutrients

To put trends in micronutrient intake over time into context, reference is made to population dietary intakes in terms of Dietary Reference Values (DRVs)[,xl] and includes commentary on mean intakes in relation to the Reference Nutrient Intake (RNI)[44] and an estimate of the proportion with intakes below the Lower Reference Nutrient Intake (LRNI).[45] All micronutrient intakes discussed in this report and presented in the associated Excel tables, exclude contribution from supplements.

Vitamin A. Intakes for vitamin A were skewed and so were log-transformed before analysis. The trends in geometric mean are reported as an average percentage change per year. A significant average yearly reduction in vitamin A intake was observed for all age/sex groups. Children aged 1.5 to 3 years, 4 to 10 years and 11 to 18 years had an average yearly reduction of 4% (CI 2, 5), 3% (CI 2, 4) and 3% (CI 2, 4) respectively. For adults intakes decreased by 2% (CI 1, 3) for those aged 19 to 64 years and 4% (CI 2, 6) for adults aged 65 years and over. The previous NDNS RP report has shown that mean intake of vitamin A was above or close to the RNI in all age/sex groups except children aged 11 to 18 years.[xx] There was a significant increase over time in the proportion with vitamin A intake below the LRNI of 2 percentage points (CI 1, 3) per year for girls aged 11 to 18 years. For most other age/sex groups there was an

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[44] The RNI for a vitamin or mineral is the amount of the nutrient that is sufficient for 97.5% of people in the group. If the average intake of the group is at the RNI, then the risk of deficiency in the group is judged to be very small. However, if the average intake is lower than the RNI then it is more likely that some of the group will have an intake below their requirement.

[45] The adequacy of vitamin or mineral intake can be expressed as the proportion of individuals with intakes below the LRNI. The LRNI for a vitamin or mineral is set at the level of intake considered likely to be sufficient to meet the needs of only 2.5% of the population. An intake below the LRNI is only considered a problem if sustained over a period of time. As diet is recorded for only 4 days in the NDNS RP, estimated intake values may not represent intakes over the longer term for micronutrients that are not widely distributed in foods such as vitamin A. It should also be noted that DRVs for some micronutrients such as magnesium, potassium, selenium and zinc are based on very limited data so caution should be used when assessing adequacy of intake using the LRNI.

increase of 1 percentage point per year, although this was not always statistically significant.

Riboflavin. An average yearly reduction in riboflavin intake of between 0.01mg/day and 0.03mg/day was seen in children: this was statistically significant for all child age/sex groups except boys aged 11 to 18 years. A significant reduction in riboflavin intake over the 9-year period was also seen in women aged 65 years and over. There was no change in the other adult age/sex groups. The previous NDNS RP report has shown that mean intake of riboflavin was above the RNI in all age/sex groups.[xx] There was a statistically significant 1 percentage point (CI 1,1) increase per year in the proportion of women aged 65 years and over with riboflavin intake below the LRNI. A 1 percentage point increase per year was also seen in girls aged 11 to 18 years, although this was not statistically significant.

Folate. A significant average yearly reduction in folate intake was observed for all age/sex groups. This was around 3-4µg/day for children and adults aged 19 to 64 years and 5µg/day (CI 3, 7) (equivalent to 45µg/day over the 9 years) for adults aged 65 years and over. The previous NDNS RP report has shown that mean intake of folate was above the RNI in all age/sex groups with the exception of girls aged 11 to 18 years.[xx] There was a statistically significant 1 percentage point increase per year in the proportion of girls aged 11 to 18 years and women aged 19 to 64 years (CI 0, 2 and 0, 1 respectively) with folate intake below the LRNI.

Vitamin D. The data for vitamin D intake were skewed and so were log-transformed before analysis. The trends in geometric mean are reported as an average percentage change per year. There was a downward trend over the the 9-year period in vitamin D intake for children aged 11 to 18 years and adults and this was statistically significant for boys aged 11 to 18 years (2% per year, CI 0, 4) and adults aged 19 to 64 years (1%, CI 0, 2). Mean intakes of vitamin D were below the RNI in all age/sex groups as indicated by the regression lines and as noted in the previous NDNS RP report.[xx]

Iron. An average yearly reduction in iron intake was seen in most age/sex groups, although this was not always statistically significant. The largest yearly reduction was seen in girls aged 4 to 10 years (0.2mg/day, CI 0.1, 0.2). There was a statistically significant increase of 2 (CI 0, 3) and 1 (CI 0, 2) percentage points in the proportion with iron intakes below the LRNI for girls aged 11 to 18 years and women aged 19 to 64 years respectively. As indicated by the regression line and as noted in the previous NDNS RP report some age/sex groups had mean intakes of iron below the RNI and substantial proportions with intakes below the LRNI, in particular girls aged 11 to 18 years and women aged 19 to 64 years.[xx,46]

Calcium. A significant average yearly reduction in calcium intake of 10mg/day was observed in children aged 1.5 to 3 years and 4 to 10 years (CI 2, 18 and 5, 14 respectively). A 5-8mg/day yearly reduction was seen in children aged 11 to 18 years and adults aged 65 years and over, although this was not statistically significant. The regression line indicates mean intake of calcium was above the RNI in all age/sex groups with the exception of boys and girls aged 11 to 18 years. There was a statistically significant 1 percentage point increase per year in the proportion of children aged 11 to 18 years and women aged 65 years and over with calcium intakes below the LRNI (CI 0, 1 for both).

Sodium. There was a significant average yearly reduction in sodium intake in all age/sex groups: the smallest change was seen in children aged 1.5 to 3 years (30mg/day, CI 18, 42) with the largest in boys aged 11 to 18 years (82mg/day, CI 61, 103). These sodium intake estimates are based on the sodium content of foods consumed. They do not fully take account of salt added during cooking and exclude salt added at the table by participants.[47]

Iodine. A downward trend in iodine intake over time was observed for most age/sex groups. Children aged 1.5 to 3 years and 4 to 10 years had a significant average yearly reduction in iodine intake of 3µg/day (CI 1, 5) and 2µg/day (CI 1, 3) respectively. Women 65 years and over had a significant average yearly reduction in iodine intake of 3µg/day (CI 1, 5). A significant average year-by-year increase in the proportion with iodine intake below the LRNI of 1 percentage point was seen in most age/sex groups. The previous NDNS RP report has shown that there was evidence of low intakes of iodine for children aged 11 to 18 years.[xx]

Magnesium. There was little change observed in magnesium intakes over the 9-year period across the age/sex groups. Women aged 65 years and over showed an average increase of 1 percentage point (CI 0, 2) per year in the proportion with magnesium intake below the LRNI. As noted in the previous NDNS report, there was evidence of low intakes of magnesium for children aged 11 to 18 years, adults aged 19 to 64 years and adults aged 65 years and over.[xx]

Potassium. A significant average yearly reduction in potassium intake of between 14mg/day and 23mg/day was seen in the child age groups. For adults, no consistent patterns over time were observed across the age/sex groups. Women aged 65 years

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[46] The adequacy of vitamin or mineral intake can be expressed as the proportion of individuals with intakes below the LRNI. The LRNI for a vitamin or mineral is set at the level of intake considered likely to be sufficient to meet the needs of only 2.5% of the population. An intake below the LRNI is only considered a problem if sustained over a period of time. As diet is recorded for only 4 days in the NDNS RP, estimated intake values may not represent intakes over the longer term for micronutrients that are not widely distributed in foods such as vitamin A. It should also be noted that DRVs for some micronutrients such as magnesium, potassium, selenium and zinc are based on very limited data so caution should be used when assessing adequacy of intake using the LRNI.
[47] A nominal 0.01g of salt is added to homemade recipes where salt has been specified by the participant as an ingredient.

and over showed an average increase of 2 percentage point (CI 1, 3) per year in the proportion with potassium intake below the LRNI. As indicated by the regression line and as noted in the previous NDNS RP report there was evidence of low intakes of potassium for children aged 11 to 18 years, adults aged 19 to 64 years and adults aged 65 years and over.[xx]

Selenium. There was little change observed in selenium intakes over the 9-year period across the age/sex groups. Women aged 19 to 64 years showed an average decrease of 1 percentage point (CI 0, 2) per year in the proportion with selenium intake below the LRNI. In contrast, women aged 65 years and over showed an average increase in the proportion with selenium intake below the LRNI of 2 percentage points (CI 0, 4). As indicated by the regression line and as noted in the previous NDNS report, there was evidence of low intakes of selenium for children aged 11 to 18 years, adults aged 19 to 64 years and adults aged 65 years and over.[xx]

Zinc. A significant average yearly reduction in zinc intake of 0.1mg/day was observed in children aged 1.5 to 3 years, girls aged 4 to 10 years, boys aged 11 to 18 years and women aged 65 years and over. The previous NDNS RP report has shown mean intake of zinc was above the RNI in all age/sex groups with the exception of girls aged 4 to 10 and 11 to 18 years.[xx] There was a statistically significant 1 percentage point increase per year in the proportion of boys aged 11 to 18 years and women aged 19 to 64 years with zinc intakes below the LRNI (CI 0, 2 and 0, 1 respectively).

Ref: Table 3.30-3.51

Chapter 4 Equivalised income (Years 5 to 9; 2012/13-2016/17) for selected foods and nutrients

4.1 Introduction

This chapter presents key findings for food consumption and nutrient intakes by equivalised household income[48] for selected key foods and nutrients for Years 5 to 9 (2012/13-2016/17) combined. The foods and nutrients were selected for their nutritional and public health relevance to current dietary concerns in the UK.

For the equivalised income analysis[48] the average change in each outcome per £10,000 increase in equivalised household income was estimated (via the slope) from a linear regression model. The analysis is shown as a plot in Excel. Refer to section 1.3 of chapter 1 for a guide to interpretation of the income analysis plots.

Many of the trends identified by the analysis were small in magnitude and some were not statistically significant. The commentary in this chapter describes trends in key foods and nutrients taking account of statistical significance (as indicated by the confidence intervals set out in brackets in the text) and whether the change is nutritionally meaningful. The text describes upward or downward trends and the overall size of any change in intake.[49] The text in this report does not describe the actual group mean for each income decile. No commentary is provided in those cases where a regression line cannot be fitted; this was either because most of the data are zero or because there is a clear non-linear relationship.

Trends in arithmetic mean are reported as ‘change per £10,000’ where the data were normally distributed and could be analysed without transformation. Where the data were skewed and needed to be log-transformed before analysis, the trends in geometric mean are reported as ‘percentage change per £10,000’ (see section 1.3 of chapter 1 for more detail).

[48] Equivalisation is a standard methodology that adjusts household income to account for different demands on resources, by considering the household size and composition.
[49] The 95% Confidence Intervals (CIs) presented in the plots relate to the magnitude and direction of change ie, negative CIs for a downward trend. In the text, downward trends are expressed as a decrease and so the CIs quoted represent the magnitude of the decrease not the direction of change.

4.2 Distribution of equivalised income data

There is evidence that the equivalised income data are positively skewed but a log transformation of these data resulted in a negative skew. Therefore no transformation was applied to the income data prior to the regression analysis, but the influence of high income responses was investigated to ensure the regression slope was not unduly affected by them.

4.3 Foods

4.3.1 Population intake

For total fruit and vegetables, total meat, and red and processed meat, and for 5 A Day fruit and vegetable portions, the proportion of non-consumers over the 4-day period was low. Therefore, the income trends in population intakes for the whole sample are presented.

Fruit and Vegetables. There was an increase in total fruit and vegetable intake with increasing equivalised income for all age/sex groups, and this was statistically significant in all groups except men aged 65 years and over. The largest increase was seen in women aged 65 years and over who consumed, on average, 32g/day (CI 18, 46) more fruit and vegetables for every £10,000 increase in equivalised income. Both total fruit intake and total vegetable intake also increased with increasing household income with, again, the largest increase in women aged 65 years and over.

5 A Day. The number of 5 A Day portions consumed are presented for the age groups for which there is a government recommendation,[xxxviii] that is for 11 to 18 years, 19 to 64 years and 65 years and over. With increasing household income, the number of 5 A Day portions consumed increased significantly for all age/sex groups, with the exception of men aged 65 years and over. The largest increase was seen in women aged 65 years and over with 0.4 portions (approximately 32g of fruit and vegetables) (CI 0.3, 0.6) for every £10,000 increase in equivalised income. For all age/sex groups where it was possible to estimate income trends, the proportion meeting the 5 A Day recommendation[xxxviii] increased with increasing household income by 2-4 percentage points for every £10,000 increase in equivalised income.

Total meat and total red and processed meat. There was no consistent pattern across the age/sex groups in terms of change in intake of total meat or red and processed meat with increasing income and the changes were small.

Ref: Table 4.1-4.5 & 4.8-4.9

4.3.2 Percent consumers and intake by consumers only

For fruit juice, white meat, fish (and oily fish) and sugar-sweetened soft drinks, trends are presented for percentage of consumers and intakes for consumers only because the proportion of non-consumers over the 4 days was high, or was high in some age/sex groups, and the inclusion of non-consumers can cause the regression analysis of the population intakes to be misleading (see section 1.3 of chapter 1).

Fruit juice. For all age/sex groups, where it was possible to estimate income trends, the percentage consuming fruit juice[50] increased significantly with increasing household income: around 3 percentage points for every £10,000 increase in equivalised income. For fruit juice consumers, there was no consistent pattern in the direction of change for fruit juice intake with increasing income across the age/sex groups. The largest changes were seen in children aged 1.5 to 3 years where intake in those who reported drinking fruit juice decreased by 7g/day (CI 1, 14) for every £10,000 increase in equivalised income while intake in girls aged 11 to 18 years who drank fruit juice increased by 11g/day (CI 3,19) for every £10,000 increase in equivalised income.

White meat. There was no consistent pattern across the age/sex groups with increasing income in terms of the percentage consuming total white meat or the intake for consumers; the changes were small or had wide confidence limits.

Total fish. There was little change in the percentage consuming fish with increasing household income. In some age/sex groups, intake of fish (consumers only) showed an increase with increasing income but the changes were small.

Oily fish. The percentage consuming oily fish increased significantly for all age/sex groups with increasing household income: for every £10,000 increase in equivalised income the percentage of consumers rose by 3 percentage points for children and 4 percentage points for adults aged 19 to 64 years. There was no consistent trend with increasing income in the amounts of oily fish eaten by consumers and the differences were small.

Sugar-sweetened soft drinks. A downward trend in the percentage consuming sugar-sweetened soft drinks with increasing household income was seen for all age/sex groups except boys aged 11 to 18 years and adults aged 65 years and over. For every £10,000 increase in equivalised income, the percentage consuming sugar-sweetened soft drinks decreased significantly for children aged 4 to 10 years (3 percentage points, CI 2, 5) and girls aged 11 to 18 years (4 percentage points, CI 2, 7). There was also a downward income trend in the quantities of sugar-sweetened soft drinks being drunk by

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[50] This includes the fruit juice component of smoothies but not smoothie fruit

consumers for all age groups except adults aged 65 years and over but this trend was only significant in boys aged 11 to 18 years and women aged 19 to 64 years.

Ref: Table 4.6-4.7, 4.10-4.17

4.4 Energy and macronutrients

In this section, reference is made to population dietary intake in terms of DRVs.[xl] Where relevant, DRVs are presented in the individual plots and are referred to as 'recommendations' in the rest of this section. The recommendations for macronutrients generally indicate the maximum contribution the nutrient should make to energy intake at the population level or, in the case of AOAC fibre, represent the recommended population average intake.

Total energy. For all age/sex groups, total energy intake increased, on average, with increasing household income, although this was not always statistically significant. The largest change was seen in adults aged 65 years and over where total energy intake increased, on average, by 0.21MJ/day (47kcal) (CI 0.12, 0.30) for every £10,000 increase in equivalised income. The same pattern was seen for food energy intake (ie, excluding energy from alcohol) for all age/sex groups.

Protein. Changes in protein intake as a percentage of food energy with respect to equivalised income were small or close to zero.

Total fat. For children aged 1.5 to 3 years total fat intake as a percentage of food energy decreased, on average, by 0.3 percentage points (CI 0.1, 0.6) for every £10,000 increase in equivalised income. For the other child age/sex groups the changes were smaller or close to zero and not in a consistent direction. For men and women aged 19 to 64 years, total fat intake as a percentage of food energy increased, on average, by 0.3 (CI 0.2, 0.5) and 0.4 percentage points (CI 0.2, 0.6) respectively for every £10,000 increase in equivalised income. For men and women aged 65 years and over, total fat intake as a percentage of food energy increased, on average, by 0.6 (CI 0.2, 1.0) and 0.9 (CI 0.1, 1.6) percentage points respectively for every £10,000 increase in equivalised income. The regression line indicates that adults in higher income groups were more likely to have total fat intakes that exceeded the recommendation.

Saturated fatty acids. Mean saturated fatty acids intake exceeded the recommendation of no more than 11% food energy across the range of equivalised income for all age/sex groups, as indicated by the regression line. For all age/sex groups, with the exception of children aged 1.5 to 3 years, saturated fatty acids intake as a percentage of food energy increased, on average, by 0.1-0.2 percentage points, although this was not always statistically significant.

***Trans* fatty acids**. Mean *trans* fatty acids intake as a percentage of food energy met the recommendation of no more than 2% food energy across the range of equivalised income for all age/sex groups, as indicated by the regression line. For every £10,000 increase in equivalised income, *trans* fatty acids intake as a percentage of food energy showed a small increase, on average, of 0.01 percentage points for most age/sex groups, although this was not always statistically significant.

Carbohydrate. For adults and children aged 11 to 18 years, carbohydrate intake as a percentage of food energy decreased with increasing household income, although this was not statistically significant for all age/sex groups. For boys aged 11 to 18 years carbohydrate as a percentage of food energy decreased, on average, by 0.3 percentage points (CI 0.0, 0.6) for every £10,000 increase in equivalised income. For adults aged 19 to 64 years, carbohydrate intake as a percentage of food energy decreased, on average, by 0.5 percentage points (CI 0.4, 0.6) for every £10,000 increase in equivalised income. For men and women aged 65 years and over, carbohydrate intake as a percentage of food energy decreased, on average, by 0.7 percentage points (CI 0.4, 1.0) and 0.9 percentage points (CI 0.1, 1.6) respectively for every £10,000 increase in equivalised income. Changes in carbohydrate intake as a percentage of food energy with increasing household income were small or close to zero for younger children.

Free sugars.[51] Mean free sugars intake exceeded the recommendation of no more than 5% total energy across the range of equivalised income for all age/sex groups, as indicated by the regression line. Adults aged 19 to 64 years showed a significant average decrease in free sugars intake as a percentage of total energy of 0.3 percentage points (CI 0.1, 0.4) for every £10,000 increase in equivalised income. For children aged 11 to 18 years and adults 65 years and over the data also suggest a decrease in free sugars intake with increasing household income, however, the trend was not statistically significant. For younger children there was no change in free sugars intake with increasing income.

AOAC fibre.[52] For all age/sex groups, AOAC fibre intake increased, on average, with increasing income. This increase was statistically significant in all age/sex groups except boys aged 11 to 18 years and men aged 19 to 64 years. Females aged 11 to 18 years, 19 to 64 years and 65 years and over showed a significant increase in AOAC fibre intake of 0.6g/day (CI 0.3, 0.8), 0.5g/day (CI 0.4, 0.7) and 0.9g/day (CI 0.2, 1.6)

[51] The definition of free sugars includes all added sugars in any form; all sugars naturally present in fruit and vegetable juices, purees and pastes, and similar products in which the structure has been broken down; all sugars in drinks (except for dairy-based drinks); and lactose and galactose added as ingredients, Further details of the methodology for determining free sugars in the NDNS RP are provided in appendix AA.
[52] AOAC fibre is the term used to describe fibre measured by the American Association of Analytical Chemists (AOAC) methods. AOAC fibre includes resistant starch and lignin in the estimation of total fibre as well as non-starch polysaccharides.

respectively for every £10,000 increase in equivalised income. In all three age groups, the increase in females was greater than seen in males.

Alcohol. For the percentage of consumers of alcohol, the data suggests a slight increase with increasing household income for those aged 11 years and over, although a regression line could not be fitted for most adult age/sex groups. For adult consumers, there was a small increase in alcohol intake as a percentage of total energy of 0.1-0.2 percentage points for every £10,000 increase in equivalised income although this was not statistically significant. Ref: Table 4.18-4.28

4.5 Micronutrients

For micronutrients, analysis has been carried out for intake and the proportion with intakes below the LRNI.[53] All micronutrient intakes discussed in this report and associated Excel tables exclude contribution from supplements. Reference is made to population intake compared with the RNI.[54] However, for the proportion with intakes below the LRNI there are very few age/sex groups where a regression line can be fitted (either due to most of the data being zero or there being a clear non-linear relationship). Therefore, no commentary is provided on this analysis in this section. For those age/sex groups where a regression line cannot be fitted, plots showing proportions per income decile are presented to aid the readers interpretation of the relationship. The relationship between the proportion with intakes below LRNI and equivalised income can be investigated further using the archived datasets.

Vitamin A. Data for vitamin A intakes were skewed and needed to be log-transformed before analysis. The trends in geometric mean are reported as an average percentage change per £10,000 increase in equivalised household income. For all age/sex groups except men aged 65 years and over, vitamin A intake increased, on average, for every £10,000 increase in equivalised income, ranging from 4% (CI 1, 6) for men aged 19 to 64 years to 9% (CI 5, 13) for girls aged 11 to 18 years. The regression line indicates that children aged 1.5 to 3 years and aged 4 to 10 years and adults aged 19 to 64 years in higher income groups were more likely to have vitamin A intakes that met the RNI.

[53] The adequacy of vitamin or mineral intake can be expressed as the proportion of individuals with intakes below the LRNI. The LRNI for a vitamin or mineral is set at the level of intake considered likely to be sufficient to meet the needs of only 2.5% of the population. An intake below the LRNI is only considered a problem if sustained over a period of time. As diet is recorded for only 4 days in the NDNS RP, estimated intake values may not represent intakes over the longer term for micronutrients that are not widely distributed in foods such as vitamin A. It should also be noted that DRVs for some micronutrients such as magnesium, potassium, selenium and zinc are based on very limited data so caution should be used when assessing adequacy of intake using the LRNI.
[54] The RNI for a vitamin or mineral is the amount of the nutrient that is sufficient for 97.5% of people in the group. If the average intake of the group is at the RNI, then the risk of deficiency in the group is judged to be very small. However, if the average intake is lower than the RNI then it is more likely that some of the group will have an intake below their requirement..

Folate. For all age/sex groups folate intake increased, on average, with increasing income. This increase ranged from 3µg/day for every £10,000 increase in equivalised income for children aged 1.5 to 3 years (CI 0, 6) and girls aged 4 to 10 years (CI 1, 6) to 8µg/day for boys aged 4 to 10 years (CI 5, 11) and adults aged 65 years and over (CI 4, 12).

Vitamin D. Data for vitamin D intakes were skewed and needed to be log-transformed before analysis. The trends in geometric mean are reported as an average percentage change per £10,000 increase in equivalised household income. Vitamin D intakes were below the RNI across the range of equivalised income for all age/sex groups, as indicated by the regression line. For all age/sex groups, with the exception of girls aged 4 to 10 and 11 to 18 years, vitamin D intake increased, on average, by 4%-6% for every £10,000 increase in equivalised income.

Iron. For all age/sex groups, iron intake increased, on average, with increasing income, although the trend was not statistically significant in all groups. The largest increase was seen in women aged 65 years and over (0.4mg/day, CI 0.1, 0.7).

Calcium. For all age/sex groups calcium intake increased, on average, with increasing income, although this was not statistically significant for all groups. The largest increases for every £10,000 increase in equivalised income were seen in boys aged 4 to 10 years (19mg/day, CI 7, 31), women aged 19 to 64 years (18mg/day, CI 10, 26) and men aged 65 years and over (37mg/day, CI 4, 69).

Sodium. For adults aged 19 to 64 years and 65 years and over, sodium intake increased on average by 39mg/day (CI 22, 56 and CI 5, 74 respectively) for every £10,000 increase in equivalised income. For children, changes in sodium intake with increasing household income were smaller and not in a consistent direction. These sodium intake estimates are based on the sodium content of foods consumed. They do not fully take account of salt added during cooking and exclude salt added at the table by participants.[55]

Iodine. For all age/sex groups iodine intake increased with increasing income, although this was not statistically significant in some groups. For every £10,000 increase in equivalised income intake in boys aged 4 to 10 years increased by 4µg/day (CI 1, 7). For adults aged 19 to 64 years and 65 years and over intake increased by 5µg/day (CI 4, 7) and 10µg/day (CI 4, 17) respectively for every £10,000 increase in equivalised income.

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[55] A nominal 0.01g of salt is added to homemade recipes where salt has been specified by the participant as an ingredient.

Magnesium. For all age/sex groups, there was an increase in magnesium intake,on average for every £10,000 increase in equivalised income and this was statistically significant for almost all age/sex groups. The largest increase was seen in women aged 65 years and over (13mg/day, CI 4, 22).

Potassium. Potassium intake increased with increasing income in all age/sex groups and was statistically significant in almost all groups . The largest increase in children was in boys aged 4 to 10 years (45mg/day, CI 25, 65). For adults aged 19 to 64 years and 65 years and over potassium intake increased, on average, by 68mg/day (CI 48, 88) and 93mg/day (CI 53, 132) respectively for every £10,000 increase in equivalised income.

Other micronutrients. For riboflavin, selenium and zinc, there were small increases with respect to equivalised income. However these were not always statistically significant. Ref: Table 4.29-4.50

Chapter 5 Time trend analysis (Years 1 to 9; 2008/09- 2016/17) for selected blood analytes

This chapter presents time trend analyses for selected measures of nutritional status over the 9-year period 2008/09-2016/17 (fieldwork years 1 to 9) of the NDNS RP. The blood analytes were selected for their nutritional and public health relevance to current dietary concerns in the UK.

The time trend analysis involves a linear regression model, which splits each survey year into quarters to more fully characterise the trends over time and provide an estimate of the average per year change over the 9-year period. The slope of the regression line represents the average year-by-year change. The analysis is shown as a plot in Excel. Refer to chapter 1 (section 1.3) for a guide to interpretation of the time trend analysis plots. To calculate the 9-year change refer to appendix U, which provides instructions on how to scale-up and explains that the calculation for variables that are analysed on the log scale is different from that for variables analysed on the linear scale. Nine-year change values are presented in tables U.1-U.4. Where a threshold has been established below (or above) which there is an indication of inadequate micronutrient status, trends over time are also reported, where appropriate, for the percentage below or above the threshold indicating suboptimal status.

Many of the trends identified by the analysis were small in magnitude and some were not statistically significant. The commentary in this chapter describes trends in key nutritional biomarkers taking account of statistical significance (as indicated by the confidence intervals set out in brackets in the text) and whether the change is physiologically meaningful. The text describes upward or downward trends and the overall size of any observed changes in biomarker levels.[56] The plots provide an indication of mean concentration for a key biomarker across the 9 years, however this report does not provide or describe the group mean values for each year. These can be found for paired years 1 to 8 in the Years 7 and 8 (combined) report.[xx] No commentary is provided in those cases where a regression line cannot be fitted; this was either because most of the data are zero or because there is a clear non-linear relationship.

Trends in arithmetic mean are reported as 'change per year' where the data were normally distributed and could be analysed without transformation. Where the data

[56] The 95% Confidence Intervals (CIs) presented in the plots relate to the magnitude and direction of change ie, negative CIs for a downward trend. In the text, downward trends are expressed as a decrease and so the CIs quoted represent the magnitude of the decrease not the direction of change.

were skewed and needed to be log-transformed before analysis, the trends in geometric mean are reported as ‘percentage change per year’ (see section 1.3 of chapter 1 for more detail).

5.1 Iron status markers - Haemoglobin and serum ferritin concentrations

Haemoglobin is the iron-containing, oxygen-carrying molecule in red blood cells; ferritin is an iron storage protein. A low haemoglobin concentration (anaemia) when coupled with low serum ferritin can indicate iron deficiency.

There was little observed change during Years 1 to 9 (2008/09 to 2016/17) in markers of iron status in any of the age/sex groups; for each age/sex group average haemoglobin and ferritin concentration were similar throughout the 9-year period as were the percentage below the lower age-appropriate threshold for haemoglobin and ferritin. Similarly no changes were seen over time when these two indices were considered together. Ref: Table 5.1-5.5

5.2 Measures of folate status - Red blood cell (RBC) and serum folate

Folate is involved in single carbon transfer (methylation) reactions, including those necessary for the synthesis of purines, pyrimidines, glycine and methionine. It is needed for DNA synthesis and thus for the production and maintenance of new cells; this particularly affects situations of rapid cell turnover. Folate deficiency can lead to macrocytic anaemia. Serum folate concentration changes rapidly, reflecting recent intake of folates and folic acid; red blood cell folate reflects folate status at the time the red blood cell was synthesised and therefore indicates average status over approximately 2 months.

5.2.1 RBC folate

The geometric mean RBC folate concentration decreased by around 2% to 4% per year in every age/sex group; the decrease was statistically significant in all age/sex groups except children aged 1.5 to 3 years and women aged 65 years and over. In women of childbearing age (16 to 49 years) the statistically significant decrease in geometric mean RBC folate concentration was 5% (CI 3, 6) per year which equates to a decrease of 34% over the 9 years.

The percentage below the clinical threshold for RBC folate concentration indicating folate deficiency (305nmol/L) increased by 1 to 2 percentage points per year in all age/sex groups in which the trend could be estimated. The percentage of women of childbearing age (16 to 49 years) with a RBC folate concentration below 748nmol/L increased by 3 percentage points (CI 1, 4; statistically significant) per year, indicating an overall increase of 23 percentage points from around two thirds to almost 90 percent over the 9 years. This indicates the percentage of women who, if they were to become pregnant, would be at increased risk of carrying a fetus affected by a folate-sensitive neural tube defect. Ref: Table 5.6-5.10

5.2.2 Serum folate

The geometric mean serum folate concentration decreased over the 9-year period (2008/09 to 2017/18) by between 2% and 4% per year in all age/sex groups; this was statistically significant in boys aged 4 to 10 years (29% decrease over 9 years), in children aged 11 to 18 years (29% decrease over 9 years), and in adults aged 19 to 64 years (27% decrease over 9 years).

Small increases (up to 1 percentage point per year) were seen in almost all age/sex groups over 11 years of age for the percentage with serum folate concentration below 7nmol/L, indicating folate deficiency. It was not possible to determine whether or not there was a trend in other age/sex groups (those aged 1.5 to 3 years or 4 to 10 years or women of childbearing age (16 to 49 years)). When data were examined in relation to the threshold of 13nmol/L, indicating possible folate deficiency, year-by-year increases in the percentage of those with a serum folate concentration lower than this threshold were seen in all age/sex groups under 65 years of age where this estimation was possible. The largest increase, 4 percentage points (CI 2, 6; statistically significant) per year, was seen in girls aged 11 to 18 years. No significant change was seen in adults aged 65 years and over. The percentage of women of childbearing age (16 to 49 years) with serum folate concentration below 13nmol/L increased significantly by 3 percentage points (CI 2, 5) per year, an overall increase of 31 percentage points over the 9 years. Ref: Table 5.11-5.16

5.3 EGRAC for riboflavin status

Erythrocyte glutathione reductase activation coefficient (EGRAC) is a measure of red cell glutathione reductase saturation with its cofactor flavin adenine dinucleotide (FAD) derived from riboflavin (vitamin B_2). The higher the EGRAC, the lower the saturation *in vitro*, and hence the greater the degree of riboflavin deficiency *in vivo*.[xli]

Small downward trends in EGRAC (indicating improving riboflavin status) over time were seen in most age/sex groups. Decreasing trends in the percentage above the currently used threshold of 1.30 were steepest in those aged 65 years and over. The trends were statistically significant in children aged 1.5 to 3 years, boys aged 4 to 10 years, women aged 19 to 64 years and men aged 65 years and over. This threshold is uncertain and therefore the 75th and 90th percentiles are also recorded for each age/sex group; although a regression line could not be fitted to these percentiles, there was no evidence of any trends in these over the 9 years. Ref: Table 5.17-5.20

5.4 Serum vitamin B_{12}

Vitamin B_{12} is a water-soluble vitamin with a key role in normal functioning of the brain and nervous system and in blood cell formation. Vitamin B_{12} status was assessed in terms of total vitamin B_{12} concentration in the serum and also that of holotranscobalamin (holoTC), the active form of vitamin B_{12} which is available for uptake into cells. The latter is a relatively new measure which is believed to be a better indicator of vitamin B_{12} deficiency and also changes faster than total vitamin B_{12} with altered dietary intake of vitamin B_{12}.[xlii]

HoloTC was only measured during Years 6 to 9 and so no time trends are presented for this analyte.

There was a statistically significant 1% (CI 0, 2) increase year on year in the geometric mean vitamin B_{12} concentration for children aged 11 to 18 years and a statistically significant 1% (Cl 1, 2) decrease year on year in the proportion of women aged 65 years and over below the threshold for low B_{12} status. In other groups, changes over time were small and not in a consistent direction and were not statistically significant.

Ref: Table 5.21-5.22

5.5 Plasma vitamin C

Vitamin C (ascorbic acid) is an antioxidant present mainly in fruits and vegetables. Its functions in the body include promotion of healing and maintenance of healthy skin, blood vessels, bones and cartilage. It is a water-soluble vitamin which is not stored in the body. Very low vitamin C levels can result in scurvy.[xl,xliii]

The mean concentration in every age/sex group is well above the threshold and in most groups the % below the threshold was too low for any conclusions to be drawn about its change over the 9 years. There was, however, a statistically significant 1 percentage point increase year-on-year in the percentage of women 19 to 64 years with vitamin C below 11µmol/L (CI 0,1) which equated to 6 percentage points over the 9 years.

Ref: Table 5.23-5.24

5.6 Plasma/serum 25-hydroxyvitamin D (25-OHD) concentration[57]

25-hydroxyvitamin D (25-OHD) concentration is a measure of vitamin D status and reflects the availability of vitamin D in the body from both dietary and endogenous sources. 25-OHD is derived from synthesis in the skin of vitamin D3 and its precursors during ultraviolet B irradiation from sunlight and from vitamin D2 and D3 and their

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[57] The matrix in which 25-OHD was measured in changed from plasma to serum during the course of the NDNS RP, refer to appendix Q for more detail.

precursors in the diet. Changes with seasonality do not affect the calculation of the time trend because individual data are used rather than annual averages and the NDNS RP covers the entire calendar equally.[xiv]

In most age/sex groups there was little change in mean 25-OHD concentration over the 9-year period 2008/09 to 2016/17. The mean 25-OHD concentration increased year-on-year in girls aged 4 to 10 years by 1nmol/L (CI 0, 3; statistically significant) and in women aged 65 years and over by 1nmol/L (CI 0, 2; statistically significant). The percentage of children aged 11 to 18 years with 25-OHD concentration below 25nmol/L increased significantly, by 1 percentage point year-on-year (12 percentage point increase over the 9 years); changes over time in the percentage of participants in the other age/sex groups with a 25-OHD concentration below this threshold were minimal. Seasonal differences in population 25-OHD concentration are discussed in chapter 7. Information about the analytical methods and matrices used during the NDNS RP is given in section Q.2.16.1 of appendix Q. Ref: Table 5.25-5.26

5.7 Serum total cholesterol:HDL cholesterol ratio

The ratio of total cholesterol: HDL cholesterol indicates the proportion of the cholesterol bound to high-density lipoproteins which carry cholesterol back to the liver for metabolism or excretion. A lower ratio has been shown in adults to indicate a lower cardiovascular risk.

Slight increases in total cholesterol:HDL cholesterol ratio over the 9-year period were seen in all age/sex groups; not all were statistically significant. Ref: Table 5.27

Chapter 6 Equivalised income (Years 5 to 9; 2012/13-2016/17) for selected blood and urinary analytes

This chapter presents key findings for selected measures of nutritional status by equivalised income[58] for selected key blood and urinary analytes for Years 5 to 9 (2012/13-2016/17) combined. The analytes were selected for their nutritional and public health relevance to current dietary concerns in the UK.

For the equivalised income analysis[58] the average change in each outcome per £10,000 increase in equivalised household income was estimated (via the slope) from a linear regression model. The analysis is shown as a plot in Excel. Refer to chapter 1 (section 1.3) for a guide to interpretation of the income analysis plots. This is the first time that blood and urine analytes have been analysed by equivalised income in the NDNS RP.

Many of the trends identified by the analysis were small in magnitude and some were not statistically significant. The commentary in this chapter describes trends in key nutritional biomarkers taking account of statistical significance (as indicated by the confidence intervals set out in brackets in the text) and whether the change is physiologically meaningful. The text describes upward or downward trends and the overall size of any change in status.[59] The text in this report does not provide or describe the group mean values for each income decile. No commentary is provided in those cases where a regression line cannot be fitted; this was either because most of the data are zero or because there is a clear non-linear relationship.

Trends in arithmetic mean are reported as 'change per £10,000' where the data were normally distributed and could be analysed without transformation. Where the data were skewed and needed to be log-transformed before analysis, the trends in geometric mean are reported as 'percentage change per £10,000' (see section 1.3 of chapter 1 for more detail).

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[58] Equivalisation is a standard methodology that adjusts household income to account for different demands on resources, by considering the household size and composition.
[59] The 95% Confidence Intervals (CIs) presented in the plots relate to the magnitude and direction of change ie, negative CIs for a downward trend. In the text, downward trends are expressed as a decrease and so the CIs quoted represent the magnitude of the decrease not the direction of change.

6.1 Distribution of equivalised income data

There is evidence that the equivalised income data are positively skewed but a log transformation of these data resulted in a negative skew. Therefore no transformation was applied to the income data prior to the regression analysis, but the influence of high income responses was investigated to ensure the regression slope was not unduly affected by them.

6.2 Iron status markers - Haemoglobin and plasma ferritin concentrations

There was no statistically significant trend with respect to income in haemoglobin concentration for any of the age/sex groups, although a non-significant increase in haemoglobin concentration with increasing equivalised income was observed in adults aged 65 years and over and in girls aged 4 to 10 years. Ferritin concentration tended to increase with increasing equivalised income in all age/sex groups except women aged 19 to 64 years and boys aged 4 to 10 years where the change was minimal. In men aged 19 to 64 years the increase was 6% (CI 2, 9; statistically significant) for every £10,000 increase in income. The greatest change was seen in adults aged 65 years and over; the increase per additional £10,000 was 9% (CI 2, 17; statistically significant).

In those age/sex groups where it was possible to estimate trends in the percentage below the threshold for ferritin concentration, changes with increasing income were minimal or not statistically significant. Ref: Table 6.1-6.5

6.3 Measures of folate status - Red blood cell (RBC) and serum folate

6.3.1 RBC folate

RBC folate concentration increased by approximately 3% per £10,000 increase in equivalised income in all age/sex groups except in women aged 65 years and over; in most age/sex groups the trend was statistically significant and it was greatest for men aged 65 years and over (10% for every £10,000 increase in income (CI 4,16). In women of childbearing age (16 to 49 years) the increase for every £10,000 increase in income was 4% (CI 1, 6; statistically significant).

The percentage of women of childbearing age with a RBC folate concentration below the threshold indicating increased risk of carrying a fetus affected by a folate-sensitive neural tube defect showed a decrease of 1 percentage point (CI -1, 3) per £10,000 increase in income, although this was not statistically significant.

It was not possible to estimate any trend in percentage with RBC folate below the clinical threshold with respect to equivalised income for any age/sex group.This was because there was no consistent pattern in the proportions per income decile. Many of the data points were zero, and for those population subgroups where data points were not zero there was no linear relationship. Ref: Table 6.6-6.10

6.3.2 Serum folate

Serum folate concentration showed an increase with respect to equivalised income for all age/sex groups except for girls aged 4 to 10 years and women aged 65 years and over. The age/sex groups with the greatest increases per additional £10,000 were children aged 1.5 to 3 years with an increase of 9% (CI 4, 15), girls aged 11 to 18 years with an increase of 8% (CI 3, 13) and men aged 65 years and over with an increase of 12% (CI 5, 19). The increase for every £10,000 increase in income in women of childbearing age (16 to 49 years) was 5% (CI 2, 8). All of these were statistically significant.

It was not possible to determine a trend with respect to equivalised income in any age/sex group in the percentage with a serum folate concentration below the clinical threshold indicating folate deficiency (7nmol/L). Where it was possible to estimate trends with respect to increasing equivalised income, decreases (with wide confidence limits) in the percentage of those with a serum folate concentration below 13nmol/L indicating possible risk of folate deficiency were seen in most age/sex groups. In women of childbearing age (16 to 49 years) the decrease per £10,000 increase in equivalised income was 2 percentage points CI (0, 5; not statistically significant).

Ref: Table 6.11-6.16

6.4 EGRAC for riboflavin status

Small downward trends in average EGRAC (erythrocyte glutathione reductase activation coefficient; lower value indicating better riboflavin status) with increasing equivalised income were seen in all age/sex groups; the decrease was only statistically significant for men aged 65 years and over (-0.01; CI 0.00, 0.02).

Where trends could be estimated in the percentage of people with EGRAC greater than 1.30, the threshold above which riboflavin deficiency is indicated, changes were minimal or had wide confidence limits. Ref: Table 6.17-6.18

6.5 Measures of serum vitamin B_{12} status

6.5.1 Serum vitamin B_{12}

The greatest increases in vitamin B_{12} concentration with respect to increasing equivalised income were seen in older adults aged 65 years and over. In men the increase for every £10,000 increase in income was 5% (CI 2, 8; statistically significant) In other age/sex groups the change was very small or with wide confidence limits.

Ref: Table 6.19-6.20

6.5.2 Serum Holotranscobalamin

Statistically significant increases were seen in holotranscobalamin; the active form of vitamin B_{12}) concentration with respect to increases with equivalised income in older men aged 65 years and over (4pmol/L (CI 1, 7)) and in boys aged 11 to 18 years (4pmol/L (CI 1, 7)). A non-significant increase was seen in children aged 4 to 10 years and no significant trend was seen in women aged 65 years and over, or in the other age/sex groups. Ref: Table 6.21

6.6 Plasma vitamin C

Increases were seen in vitamin C concentration with respect to equivalised income in older children and most adult age/sex groups. These increases were statistically significant and greatest in girls aged 11 to 18 years at 3µmol/L (CI 1, 4) per additional £10,000, in adults aged 19 to 64 years at 2µmol/L (CI 1, 2) and in women aged 65 years and over (3µmol/L (CI 1, 4)). No change was observed in vitamin C concentration with respect to equivalised income in children aged 1.5 to 3 years, in boys aged 4 to 10 years or in men aged 65 years and over. Ref: Table 6.24-6.25

6.7 Plasma/serum 25-hydroxyvitamin D (25-OHD)[60]

Increases in 25-OHD with respect to increasing equivalised income were seen in all age/sex groups except in girls aged 4 to 10 years. The increase was most marked in children aged 1.5 to 3 years where the increase for every £10,000 increase in income was 4nmol/L (CI 1, 7; statistically significant) and in children aged 11 to 18 years in whom the increase was 3nmol/L (CI 2, 5; statistically significant); similar for boys and girls. Smaller but statistically significant increases for every £10,000 increase in equivalised income were observed in adults aged 65 years and over (2nmol/L (CI 0, 3)), and in adults aged 19 to 64 years (1nmol/L (CI 0, 1)).

It was not possible to estimate any trends in the percentage of those with a 25-OHD concentration below 25nmol/L with respect to equivalised income, because the absence of a linear relationship meant that no regression line could be fitted.

Information about the analytical methods and matrices used during the NDNS RP is given in section Q.2.16.1 of appendix Q

[60] The matrix in which 25-OHD was measured in changed from plasma to serum during the course of the NDNS RP, refer to appendix Q for more detail.

6.8 Serum total cholesterol:HDL cholesterol ratio

Total cholesterol:HDL cholesterol ratio decreased slightly with respect to increasing equivalised income in children and in adults aged 19 to 64 years; in most age/sex groups this was not statistically significant. In children aged 11 to 18 years the decrease in the ratio for every £10,000 increase in income was 0.1 (CI 0.0, 0.1; statistically significant); in children aged 1.5 to 3 years it was 0.1 (CI 0.0, 0.2; not statistically significant) and in other age/sex groups the change was smaller. No trend with equivalised income was seen in those aged 65 years and over. Ref: Table 6.28

6.9 Urinary iodine

6.9.1 Urinary iodine concentration (spot urine)

Any spot urine concentration depends on many factors, including hydration status of the participant at the time the urine was passed as well as recent intake. Spot urinary iodine concentrations do not represent the iodine status of individuals, but the median of a large number of spot urine concentrations indicates the iodine sufficiency or otherwise of a population, and when population spot urine iodine concentration data are combined (as for the regression analysis) they can indicate population trends.[xliv]

No trends in spot urinary iodine concentration with equivalised income were observed for any age/sex group with the exception of women aged 19 to 64 years for whom there was a statistically significant decrease in spot urinary iodine concentration with increasing equivalised income of 4% (CI 1, 7) per £10,000 and men aged 65 years and over for whom there was a non-significant increase in spot urinary iodine concentration with increasing equivalised income of 5% (CI 0, 10) per £10,000. Ref: Table 6.29

Chapter 7 Plasma/serum 25-hydroxyvitamin D (25-OHD) (Years 1 to 9; 2008/09-2016/17) by season[61]

25-hydroxyvitamin D (25-OHD) is synthesised in the skin when exposed to sunlight. The required wavelengths only penetrate the earth's atmosphere when the sun is overhead; 25-OHD synthesis is prevented by high-factor sunscreens and UV-opaque clothing. 25-OHD persists in the body for several weeks and therefore after sun exposure the blood concentration tends to drop gradually; however this is offset by oral intake of vitamin D in foods and supplements. SACN advise that a 25-OHD concentration below 25nmol/L indicates risk of deficiency.[62]

In NDNS RP a single blood sample was taken from each participant and on a population basis this was spread evenly throughout the year. No participant had blood taken in more than one quarter of the year. Population 25-OHD concentration data for the first 9 years (2008/09 to 2016/17) of the NDNS RP have been combined and then split seasonally by date of blood sample to demonstrate these changes in the four quarters of the year; January to March, April to June, July to September and October to December. The UK spans a range of latitudes (51^0N to 58^0N) which in this analysis are considered together. The 9-year data collection did not yield sufficient measurements in children 1.5 to 3 years for this age group to be included in the seasonality analysis.

7.1 Mean 25-OHD concentrations

During the 9 years of the NDNS RP, 25-OHD concentrations during January-March were below 25nmol/L for 19% of children aged 4 to 10 years, 37% of children aged 11 to 18 years, 29% of adults aged 19 to 64 years and 27% of older adults aged 65 years and over.

In all of the age/sex groups, mean 25-OHD concentrations were lowest during January-March, highest during July-September and intermediate in the other 2 quarters of the year. Mean 25-OHD concentrations in each age/sex group were about 10nmol/L higher in July-September than in October-December and most age/sex groups were lower by a further 10nmol/L during January-March. Nearly all changes from each quarter to the next

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[61] The matrix in which 25-OHD was measured in changed from plasma to serum during the course of the NDNS RP, refer to appendix Q for more detail.

[62] The Scientific Advisory Committee on Nutrition (SACN) vitamin D and health report published in 2016 recommended an RNI of 10µg/day for those aged 4 years and over and a safe intake of 10µg/day for those aged 1 to 4 years.

quarter were statistically significant at the 5% level, particularly when the difference was more than about 5nmol/L.

In general, mean 25-OHD concentrations were highest in children aged 4 to 10 years in all quarters of the year..

The drop in population mean 25-OHD concentration in older women between October-December (44.5nmol/L) and January-March (42.7nmol/L) was much less than any other age/sex group (see above; approximately 10nmol/L drop) and was not statistically significant (difference -1.8nmol/L (CI -8.1, 4.4). Similarly the population mean concentration in this group rose towards summer levels earlier in the year than other age/sex groups, increasing to 51.6nmol/L in April-June, which was only 2.2nmol/L (CI -5.1, 9.4) less than the mean in July-September (53.8nmol/L).

7.2 Percentage with 25-OHD below 25nmol/L

During January-March 19% of children aged 4 to 10 years (25% of girls, 14% of boys) and 37% of children aged 11 to 18 years (34% of girls, 40% of boys) had a 25-OHD concentration below 25nmol/L. During April-June the proportion below the threshold decreased to 7% of children aged 4 to 10 years (10% of girls, 3% of boys) and 13% of children aged 11 to 18 years (20% of girls, 6% of boys).

During July-September, 6% of children aged 11 to 18 years (8% of girls and 4% of boys) had a 25-OHD concentration below the threshold, but no children aged 4 to 10 years had 25-OHD below 25nmol/L. Percentages increased in October-December when 5% of children aged 4 to 10 years (6% of girls, 5% of boys) and 20% of children aged 11 to 18 years (25% of girls, 15% of boys) had a 25-OHD concentration below 25nmol/L.

During January-March 29% of adults aged 19 to 64 years (28% of women, 30% of men) and 27% of adults aged 65 years and over (24% of women, 32% of men) had a serum 25-OHD concentration below 25nmol/L. During April-June this decreased to 19% of adults aged 19 to 64 years (16% of women, 22% of men) and 9% of adults aged 65 years and over (9% of women, 9% of men).

During July-September, 4% of adults aged 19 to 64 years (5% of women, 4% of men) and 4% of adults aged 65 years and over (6% of women, 1% of men) had a 25-OHD concentration below 25nmol/L. Percentages increased in October-December when 15% of adults aged 19 to 64 years (10% of women, 20% of men) and 15% of adults aged 65 years and over (15% of women, 14% of men) had a 25-OHD concentration below 25nmol/L.

For detail about the laboratory methods and analytical matrix see section Q.2.16.1 of appendix Q.

Ref: Table 7.1

Chapter 8 Foods consumed (Years 5 to 9 combined; 2012/13-2016/17) (Tables only)

The latest descriptive statistics for Years 5 to 9 (combined) (2012/13-2016/17) are provided for consumption of standard NDNS food groups for the total sample (including non-consumers) and for consumers only for the standard NDNS age groups (sex-split and sex-combined). No commentary is provided for these tables on foods consumed. See appendix R of the previous report[xx] for more information about the standard NDNS food groups.

Commentary is available in an earlier report for the Years 1 to 4 (combined) data period for consumption of standard NDNS food groups[ix] and in intervening paired-years reports for consumption of disaggregated foods (fruit and vegetables, meat and fish) and sugar-sweetened soft drinks.[xx,xix] No statistical analyses have been undertaken in this report to compare the Years 5 to 9 (combined) data for consumption of standard NDNS food groups with equivalent Years 1 to 4 (combined) data.

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