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

National Diet and Nutrition Survey

Headline results from Years 1, 2 and 3 (combined) of the Rolling Programme (2008/2009 – 2010/11)

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Authors' acknowledgements

We would like to thank all of those who gave up their time to be interviewed and who welcomed interviewers and nurses into their homes. We would also like to acknowledge the professionalism and commitment of interviewers and nurses who worked on the survey and who are so important to the survey's success.

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

- Members of the teams at Natcen: Caireen Roberts, Katharine Sadler, Valdeep Gill, Rosie Sutton, Lizzie Hacker, Sarah Tipping and Sam Clemens; HNR: Polly Page, Toni Steer, Sonja Nicholson, Birgit Teucher, Polly Page, Gerda Pot, Priti Mistry Katie Dearnley and Adam Messenger; and UCL: Jennifer Mindell and Alison Moody.
- Stuart Bennett and colleagues at the Northern Ireland Statistics and Research Agency for organising and carrying out fieldwork in Northern Ireland.
- Operations staff at Natcen, especially Pauline Burge, Lynne Gold and Coral Lawson.
- The programmers and data managers at Natcen: Steve Edwards, Claire Deverill and Olu Alaka; and at HNR: Darren Cole, Gemma Bramwell, Jonathan Last, Iain Bayes, Kerry Lambert and Alison James.
- The dietary assessment team at HNR: Celia Greenberg, Emily Fitt, Elizabeth Stickley, Clare Whitton, Natalie Momen, Kate Edgecombe, Lindi Holmes, Dorothy Singer, Rachel Woodward, Kirsty Trigg, David Pell, Nida Ziauddeen, Anna Harvey, Jenny Winster, Rachael Mack, Karen Binks and Tsz Ning Mak.
- Laboratory and analytical personnel at HNR: Lorna Cox, Christine Clewes, Les Bluck, Steve Austin, Sylvaine Bruggraber, Amanda McKillion, Peter Winship, Stephen Young, Antony Wright, Kate Guberg, Karen Chamberlain, Hanneke Mfuni, Abhilash Krishnankutty, Tabasum Makhdoomi, Debbie Harman, Michelle Lewin, Maria Pinheiro, Laura Angell, Oliver Tunnacliffe Marilena Leventi, Carl Ruffel, Deepti Sood, Vijay Vaja, Carmen Canas, Edyta Telega, Veronica Bell and Falai Baldeh.
- Other colleagues at HNR: Sue Bryant, Yvette Edwards, Adrian Mander, Ashley Olson and Mark Chatfield.

- Other colleagues at UCL: Maria Aresu, Barbara Carter-Szatynska, Marilyn Roth and Emmanuel Stamatakis.
- Colleagues at Addenbrookes for carrying out blood analyses and Professor Elaine Gunter (Centre for Disease Control and Prevention, USA) for an independent review of the laboratory procedures and analyses.
- Soren Brage and colleagues at the MRC Epidemiology Unit for their physical activity expertise.
- Members of the NDNS Project Board and external advisors, in particular the late Professor Sheila Bingham, Dr Ailsa Welch, Dr Wendy Wrieden, Professor Julie Lovegrove and Professor Hilary Powers.
- The professional staff at the Department of Health in particular:Jane Barrett, Mark Bush, Mary Day, Sakhi Dodhia, Melanie Farron-Wilson, Andrew James, Verity Kirkpatrick, Sheela Reddy, Alison Tedstone and Frederick Wheeler.
- The professional staff at the Food Standards Agency: Fiona Comrie, Sinead Furey, Clifton Gay, Maria Jennings, Anne Milne, Heather Peace, Gillian Purdon and Joseph Shavila.
- The professional staff at the Welsh Government: Sarah Rowles and Chris Roberts

Notes to text and tables

1 The data used in the report have been weighted. The weighting is described in Appendix B of this report. Unweighted sample sizes are shown at the foot of each table.

2 Two different non-response weights have been used: one for non-response at the interview stage (with adult and child versions) and one for non-response to the nurse visit (again, with adult and child versions). In addition, the Smoking and Alcohol sections in Chapter 3 use a separate weight which allows 16-18 year olds to be included in analysis of adults.

3 The data in Chapters 3 and 4 were analysed in SPSS version 15 using the complex surveys module. The data in Chapters 5 and 6 were analysed in SPSS versions18.0 and 14.0 respectively without the complex surveys module.

4 The following conventions have been used in tables:

- `-` no observations (zero value)
- `0` non-zero values of less than 0.5% and thus rounded to zero
- `[ ]` used to warn of small sample bases, if the unweighted base is less than 30.

5 Because of rounding, row or column percentages may not add exactly to 100%.

6 A percentage may be quoted in the text for a single category that aggregates two or more of the percentages shown in a table. The percentage for the single category may, because of rounding, differ by one percentage point from the sum of the percentages in the table.

7 Values for means, medians, percentiles and standard errors are shown to an appropriate number of decimal places. For reasons of space, Standard Error may sometimes be abbreviated to SE and Standard Deviation to sd.

8 'Missing values' occur for several reasons, including refusal or inability to answer a particular question; refusal to co-operate in an entire section of the survey (such as the nurse visit or a self-completion questionnaire); and cases where the question is not applicable to the participant. In general, missing values have been omitted from all tables and analyses.

9 The group to whom each table refers is stated at the upper left corner of the table.

10 The term 'significant' refers to statistical significance (at the 95% level) and is not intended to imply substantive importance.

6.5.1 Total cholesterol, high density lipoprotein (HDL) cholesterol and low density lipoprotein (LDL) cholesterol (*millimoles/litre, mmol/L*)

6.6 Selenium and zinc

6.6.1 Plasma selenium (*micromoles/litre, μmol/L*)

6.6.2 Plasma zinc (*micromoles/litre, μmol/L*)

[1] Appendix K is unchanged from the version published as part of the Year 1 and 2 (combined) report

N.2.4 Serum total, high density lipoprotein (HDL) and low density lipoprotein (LDL) cholesterol

N.2.4.1 Internal quality controls for total cholesterol

N.2.4.2 Internal quality controls for HDL cholesterol

N.2.4.3 External quality controls for total and HDL cholesterol

N.2.5 Serum triglycerides (triacylglycerols)

N.2.5.1 Internal quality controls for serum triglycerides (triacylglycerols)

N.2.5.2 External quality controls for serum triglycerides (triacylglycerols)

N.2.6 Plasma ferritin

N.2.6.1 Quality controls for plasma ferritin

N.2.6.2 External quality controls for ferritin

N.2.7 Plasma transferrin receptors

N.2.7.1 Quality controls for plasma transferrin receptors

N.2.8 Plasma vitamin C

N.2.8.1 Internal quality controls for vitamin C

N.2.8.2 External quality controls for vitamin C

N.2.9 Erythrocyte transketolase activation coefficient (ETKAC) for thiamin status

N.2.9.1 Quality controls for ETKAC

N.2.10 Erythrocyte glutathione reductase activation coefficient (EGRAC) for riboflavin status

N.2.10.1 Quality controls for EGRAC

N.2.10.1.1 Internal quality controls

N.2.11 Plasma vitamin B_6 (PLP and PA)

N.2.11.1 Quality controls for vitamin B_6

N.2.11.1.1 Internal quality controls for vitamin B_6

N.2.12 Plasma total homocysteine

N.2.12.1 Quality controls for plasma total homocysteine

N.2.12.1.1 Internal quality controls for plasma total homocysteine

N.2.13 Plasma retinol, retinyl palmitate, α- and γ–tocopherol and individual carotenoids

N.2.13.1 Quality controls for plasma retinol, retinyl palmitate, α- and γ–tocopherol and individual carotenoids

N.2.13.1.1 Internal quality controls for plasma retinol, retinyl palmitate

N.2.13.1.2 External quality controls for plasma retinol, retinyl palmitate, α- and γ–tocopherol and individual carotenoids

N.2.14 Plasma 25-hydroxyvitamin D (25-OHD)

N.2.14.1 Quality controls for 25-OHD

N.2.14.1.1 Internal quality controls for 25-OHD

N.2.14.1.2 External quality controls for 25-OHD

N.2.15 Plasma creatinine

National Diet and Nutrition Survey: headline results from Years 1, 2 and 3 combined (2008/9 – 2010/11)

Executive Summary

Introduction

The National Diet and Nutrition Survey (NDNS) is a programme of surveys 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 NDNS is jointly funded by the Department of Health (DH) in England and the UK Food Standards Agency (FSA)[1] and carried out by a consortium of three organisations: NatCen Social Research (NatCen), MRC Human Nutrition Research (HNR) and the University College London Medical School (UCL). The NDNS programme began in 1992 and comprised a series of cross-sectional surveys, each covering a different age group: pre-school children (aged 1.5 to 4.5 years);[2] young people (aged 4 to 18 years);[3] adults (aged 19 to 64 years)[4] and older adults (aged 65 years and over).[5] Since 2008 the NDNS has been a rolling programme for people aged 1.5 years and over.

The NDNS provides the only source of high quality nationally representative data on the types and quantities of foods consumed by individuals, from which estimates of nutrient intakes are derived.[6] Methods used in the NDNS are continually reviewed to ensure they remain the best practical methods available. Results are used by Government to develop policy and monitor progress on diet and nutrition objectives of UK Health Departments, for example those set out in the Healthy Lives Healthy People White Paper in England.[7] The food consumption data are also used by 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.

This report presents combined results from Years 1, 2 and 3 of the rolling programme (2008/09 – 2010/11) for a sample of the UK population designed to be nationally representative. This report supersedes and replaces previous reports for the NDNS rolling programme,[8] providing a larger sample size.

Sample and response rates

A sample of 9,990 addresses from 370 postcode sectors, drawn from the UK Postcode Address File, was issued between April 2008 and March 2011. Where there were multiple households at an address a single household was selected at random. For each household, either one adult and one child, or one child only were selected for inclusion.[9] Selected individuals were asked to complete a diary of food consumption over four days. The survey also included an interview to collect background information on dietary habits, socio-demographic status and lifestyle, collection of a blood sample to assess biochemical indices of nutritional status and a 24-hour urine collection to assess salt intake.

The response rate for completion of the diary was 55% in Year 1 and Year 2 and 52% in Year 3. A total of 3,073 individuals aged 1.5 years and older completed diaries (1,491 adults aged 19 years and over and 1,582 children aged 1.5 to 18 years). Some participants dropped out when asked to agree to a nurse visit and a further percentage declined to give a blood sample. In Years 1, 2 and 3 (combined), 50% of adults aged 19 to 64 years (582) and 38% of children aged 11 to 18 years (256) who had completed a diary went on to give a blood sample.[10]

The data are weighted to minimise any bias in the observed results which may be due to differences in the probability of households and individuals being selected to take part; and to attempt to reduce non-response bias.[11]

Contents of this report

The results in this report cover the following areas:

- Consumption of NDNS food groups based on food and composite dishes as eaten
- Consumption of meat, fish, fruit and vegetables using ‘disaggregated’ data for composite dishes
- The number of portions of fruit and vegetables consumed (calculated using ‘disaggregated’ data for composite dishes) and the proportion of participants meeting the “5-a-day” recommendation

- Intakes of energy, macronutrients (protein, fat and fatty acids, carbohydrates) and alcohol; Comparison of nutrient intakes with UK Dietary Reference Values (DRVs)[12]
- Comparison of selected vitamin and mineral intakes with UK DRVs, including and excluding dietary supplements
- Use of dietary supplements
- Blood status indicators for the following micronutrients: iron; vitamin C; vitamin B_{12}; vitamin B_1 (thiamin); vitamin B_2 (riboflavin); vitamin B_6; vitamin A (retinol and carotenoids); vitamin D; vitamin E; selenium; zinc. Results are also reported for blood lipids, homocysteine and C-reactive protein.[13]

Diet and nutrition recommendations

Recommendations for consumption of fruit and vegetables and oily fish are shown below.

	Recommendation
Fruit and vegetables	At least 5 portions per day (equivalent to 400 grams for adults)
Oily fish	1 portion per week (140g)

Key DRVs for macronutrients are shown below. These apply to the whole population over the age of five years.

Macronutrient	**Dietary Reference Value**
Total fat	Population average no more than 35% food energy
Saturated fatty acids	Population average no more than 11% food energy
Trans fatty acids	Population average no more than 2% food energy
Non-milk extrinsic sugars (NMES)	Population average no more than 11% food energy
Non-starch polysaccharides (NSP)	Adult population average at least 18g per day

Adequacy of micronutrient intake is assessed by comparing intake with age/sex specific DRVs for each vitamin and mineral. Mean intake is compared with the Reference Nutrient Intake (RNI)[14] and the proportion with intakes below the Lower Reference Nutrient Intake (LRNI)[15] is assessed. The RNIs and LRNIs set for each vitamin and mineral are shown in tables 5.14 and 5.18.

There is also a recommendation that salt intake should not exceed the recommended maximum of no more than 6g/day. Information from the NDNS on salt intake in adults was published in June 2012.[16]

Blood analyte measures are compared with threshold values where these have been set. These generally indicate the proportion of people at greater risk of deficiency of a nutrient due to depleted body stores or tissue levels.[13]

With the exception of the blood analytes, results are presented for five age groups: 1.5 to 3 years; 4 to 10 years; 11 to 18 years; 19 to 64 years; 65 years and over, split by sex in all except the youngest age group. The results from analysis of blood samples for Years 1, 2 and 3 (combined) are presented for children aged 11 to 18 years and adults aged 19 to 64 years. Blood samples were also collected from participants aged 1.5 to 10 years and 65 years and over and these will be reported in the future when sample numbers have increased.

The report also includes the heights, weights, blood pressure and socio-demographic characteristics of the participants. These were in line with the general UK population which suggests that the sample was nationally representative.

Key findings

In general, the results in this report confirm those published last year in the Years 1 and 2 (combined) report.[8]

- Adults aged 19 to 64 years on average consumed 4.1 portions of fruit and vegetables per day (including the contribution from composite dishes) and older adults (i.e. those aged 65 years and over) 4.4 portions. 31% of adults and 37% of older adults met the "5-a-day" recommendation.[17]
- Mean consumption of fruit and vegetables for children aged 11 to 18 years was 3.0 portions per day for boys and 2.8 portions per day for girls. 11% of boys and 8% of girls in this age group met the "5-a-day" recommendation.
- Mean consumption of oily fish was well below the recommended one portion (140g) per week in all age groups. For example, mean consumption in adults aged 19 to 64 years was equivalent to 54g per week.
- Mean energy intakes for adults were 1882 kcal/day for those aged 19 to 64 years (2151 kcal/day for men and 1614 kcal/day for women) and 1690 kcal/day for adults aged 65 years and over (1934 kcal/day for men and 1501 kcal/day for women). In children mean energy intakes ranged from 1137 kcal/day for children aged 1.5 to 3 years, 1555 kcal/day for children aged 4 to 10 years and 1791 kcal/day for children aged 11 to 18 years.
- Mean intake of total fat met the DRV (no more than 35% food energy) in all age/sex groups except for men and women aged 65 years and over, for whom, on average, total fat provided 36.9% and 35.4% food energy respectively.
- Mean intakes of saturated fat exceeded the DRV (no more than 11% food energy) in all age groups. For example, mean saturated fat intake for adults aged 19 to 64 years was 12.7% food energy.

- Mean intakes of *trans* fatty acids provided 0.7-0.8% of food energy for all age groups, thus meeting the DRV (no more than 2% food energy).
- Mean NMES intakes exceeded the DRV (no more than 11% food energy) for all age groups most notably for children aged 11 to 18 years where mean intakes provided 15.3% food energy.
- 58% of adults aged 19 to 64 years and 52% of adults aged 65 years and over consumed alcohol during the four-day recording period. Adults aged 19 to 64 years who consumed alcohol during the four-day recording period obtained 9% of energy intake from alcohol; older adult consumers obtained 7%.
- Mean intakes of Non-Starch Polysaccharides (NSP) for adults aged 19 years and over were 13.3-13.8g per day, below the DRV set for adults of at least 18g per day.
- Mean intakes of reported vitamins (except vitamin D) from food sources were close to or above the Reference Nutrient Intake (RNI)[14] for all groups. Intakes of vitamin D were below the RNI even after including the contribution from dietary supplements.[18] For children aged 11 to 18 years, 13% had vitamin A intakes and 21% of girls had riboflavin intakes below the Lower Reference Nutrient Intake (LRNI).[15] The contribution of dietary supplements did not reduce the proportions below the LRNI.
- Mean intakes of reported minerals from food sources were below the RNI for some age groups, in particular children aged 11 to 18 years. In addition, a substantial proportion of this age group, particularly girls, had intakes below the LRNI. Mean intakes of iron were below the RNI for girls aged 11 to 18 years and women aged 19 to 64 years and 46% of girls and 23% of women aged 19 to 64 years were below the LRNI. Use of supplements had little effect on the proportions below the LRNI. Mean intakes of all minerals were above the RNIs for younger children aged under 11 years and few children in this age group had intakes below the LRNI.
- 23% of adults aged 19 to 64 years and 39% of adults aged 65 years and over reported taking at least one dietary supplement during the four-day recording period.
- There is evidence of iron-deficiency anaemia (as indicated by low haemoglobin levels) and low iron stores (plasma ferritin) in a proportion of adult women and older girls. The proportion of girls aged 11 to 18 years and women aged 19 to 64 years who had a haemoglobin and ferritin concentration below the lower limit of the

normal range were 5.6% and 3.3% respectively. Iron deficiency anaemia has health implications.

- There is evidence of low vitamin D status in adults aged 19 to 64 years and children aged 11 to 18 years, both male and female. The proportion of boys and girls aged 11 to 18 years and men and women aged 19 to 64 years who had 25-OHD concentrations below the lower threshold for vitamin D adequacy was 19.3%, 20.4%, 17.1% and 18.6% respectively. This has implications for bone health, including increased risk of rickets and osteomalacia.
- A substantial proportion of adults and older children have erythrocyte glutathione reductase activation co-efficient (EGRAC) values above the generally accepted upper threshold for normal riboflavin (vitamin B2) status. However recent research has suggested that this threshold (1.30) may be set too low, so overestimating the prevalence of low riboflavin status.
- There is little evidence of low status for other micronutrients where normal ranges or thresholds for low status have been set. Mean values for vitamin C, B_{12}, thiamin, retinol (vitamin A)[19] and vitamin E fell within the normal range.
- Nearly half of adults had elevated concentrations of serum total cholesterol associated with increasing risk of cardiovascular disease. This is well known and in line with findings from health surveys.

Methodological issues

Misreporting of food consumption

Misreporting of food consumption, generally under-reporting, is known to be an issue in NDNS as in all dietary surveys. The degree of under-reporting needs to be borne in mind when interpreting findings from this survey. The doubly-labelled water (DLW) technique has been used to measure total energy expenditure in a sub-sample of NDNS participants to assess the extent of misreporting of energy intake. Results of the DLW analyses will be published at a later date.

Diet and nutritional status

Results based on assessment of food consumption over the four-day diary period tell us about diet over a relatively short period. Analysis of blood samples can provide an indication of the nutritional status of the population over a longer period. Nutritional status is the level of nutrients available to the body (after absorption) for use in metabolic processes.

It is not possible to make direct comparisons between the dietary results and blood results presented in the report partly due to the elapsed time between the diary recording period and blood sampling (a gap of at least eight weeks in Year 2 onwards) and also because many of the blood indicators reflect longer term body stores of a nutrient rather than recent intake.

Differences between the previous surveys and the current rolling programme

There are a number of methodological differences between the previous cross-sectional surveys and the current rolling programme. The surveys of adults aged 19 to 64 years and children aged 4 to 18 years used a seven-day diary whereas the current survey uses a four-day diary. The survey of children aged 1.5 to 4.5 years used a four-day diary which over-sampled weekend days. Differences in number of days have little effect on comparisons of mean consumption of food groups or mean nutrient intakes between surveys but do affect comparisons for percentages consuming food groups and meeting dietary recommendations. Another key methodological difference is that all the previous

surveys used weighed diaries whereas the rolling programme uses estimated weights for quantities eaten.

For blood analytes, the current rolling programme collects blood samples following an overnight fast for all age groups (except those aged 1.5 to three years and diabetics not willing to fast who are asked to provide a non-fasting blood sample). Data from fasting blood samples are considered to be more informative because some analytes are affected by recent food consumption. This is a change in methodology from the previous NDNS of adults aged 19 to 64 years carried out in 2000/01, which collected non-fasting samples and means that comparisons with that survey cannot be made for nutrients affected by recent consumption. In addition, some of the analytical methods have changed since previous NDNS in 1997 and 2000/01 and the new analytical methods are not always comparable with those used in the previous surveys. Because of these methodological changes we have not made comparisons between the blood results in this report with those in previous NDNS surveys.

Future reports

Combined data for Years 1-4 of the rolling programme are due to be published in 2013. That report will update information about food consumption and nutrient intakes and will include comparisons within the rolling programme i.e. Years 1 & 2 combined vs Years 3 & 4 combined. Results from blood analytes will be provided, including, for the first time, results for older adults (aged 65 years and over) and younger children (aged 1.5 to 10 years). The report will also contain results from 24-hour urine analyses and an assessment of physical activity.

[1] Responsibility for nutrition policy in England and Wales transferred from FSA to Health Departments in 2010. Management of NDNS also transferred to the Department of Health in England at that time.

[2] Gregory JR, Collins DL, Davies PSW, Hughes JM, Clarke PC. National Diet and Nutrition Survey: children aged 1 ½ to 4 ½ years. Volume 1: Report of the diet and nutrition survey London: HMSO, 1995.

Hinds K, Gregory JR. National Diet and Nutrition Survey: children aged 1½ to 4½ years. Volume 2: Report of dental survey. London: HMSO, 1995

[3] Gregory JR, Lowe S, Bates CJ, Prentice A, Jackson LV, Smithers G, Wenlock R, Farron H. National Diet and Nutrition Survey: young people aged 4 to 18 years. Volume 1: Report of the diet and nutrition survey. London: TSO, 2000.

Walker A, Gregory J, Bradnock G, Nunn J, & White D. National Diet and Nutrition Survey: young people aged 4 to 18 years. Volume 2: Report of the oral health survey. London: TSO, 2000

[4] Henderson L, Gregory J, Swan G. National Diet and Nutrition Survey: adults aged 19 to 64 years. Volume 1: Types and quantities of food consumed. London: TSO, 2002.

Henderson L, Gregory J, Irving K, Swan G. National Diet and Nutrition Survey: adults aged 19 to 64 years. Volume 2: Energy, protein, carbohydrate, fat and alcohol intake. London: TSO, 2002.

Henderson L, Irving K, Gregory J, Bates CJ, Prentice A, Perks J, Swan G, Farron M. National Diet and Nutrition Survey: adults aged 19 to 64 years. Volume 3: Vitamin and mineral intake and urinary analytes. London: TSO, 2003.

Rustin D, Hoare J, Henderson L, Gregory J, Bates CJ, Prentice A, Birch M. National Diet and Nutrition Survey: adults aged 19 to 64 years. Volume 4: Nutritional status (anthropometry and blood analytes), blood pressure and physical activity. London: TSO, 2004

Hoare J, Henderson L, Bates CJ, Prentice A, Birch M, Swan G, Farron M. National Diet and Nutrition Survey: adults aged 19 to 64 years. Volume 5: Summary report. London: TSO, 2004

[5] Finch S, Doyle W, Lowe C, Bates CJ, Prentice A, Smithers G, Clarke PC. National Diet and Nutrition Survey: people aged 65 years and over. Volume 1: Report of the diet and nutrition survey. London: TSO, 1998.

Steele JG, Sheiham A, Marcenes W, Walls AWG. National Diet and Nutrition Survey: people aged 65 years and over. Volume 2: Report of the oral health survey. London: TSO, 1998

[6] Ashwell M, Barlow S, Gibson S, Harris C (2006) National Diet and Nutrition Surveys: the British experience. Public Health Nutrition 9(4) 523-530

[7] Department of Health Healthy Lives, Healthy People: Our Strategy for public health in England White Paper [Online] Available: http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_121941 (accessed 04/05/2012)

[8] Bates B, Lennox A, Swan G (2010) National Diet and Nutrition Survey; Headline results from year 1 of the rolling programme (2008/09) [Online]. Available: http://tna.europarchive.org/20110116113217/tna.europarchive.org/20110116113217/http://www.food.gov.uk/science/dietarysurveys/ndnsdocuments/ndns0809year1 (accessed 02/02/12)

Bates B, Lennox A, Bates C, Swan G (2011) National Diet and Nutrition Survey; Headline results from years 1 and 2 (combined) of the rolling programme (2008/09- 2009/10) [Online]. Available: http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsStatistics/DH_128166 (accessed 02/02/12).

[9] In some core sample households (where up to one adult and one child could be selected), it was possible to end up with an adult participant only, either because the selected child was not able/did not wish to take part or because there was no resident child eligible for selection.

[10] All individuals visited by a nurse were asked if they were willing to provide a blood sample. Blood results for older adults (aged 65 years and over) and younger children (aged 1.5 to 10 years) are not included in this report but will be included in future reports when sufficient numbers have been accumulated.

[11] Non response bias occurs if those who respond to the survey (or elements of the survey) differ from those who do not respond. Data were weighted to reduce such bias.

[12] Report on Health and Social Subjects 41 *Dietary Reference Values (DRVs) for Food Energy and Nutrients for the UK*, Report of the Panel on DRVs of the Committee on Medical Aspects of Food Policy (COMA) 1991. The Stationery Office. London

[13] For some micronutrients, status can be assessed by directly measuring the level of the nutrient in blood, while for others it is assessed by a functional measure such as the activity of vitamin-dependent enzymes. For example, riboflavin status can be assessed by measuring the activity of the red cell enzyme glutathione reductase which is dependent on a co-factor derived from riboflavin. Threshold values, below or above which low status is indicated, have been set for some, though not all, micronutrients. A value indicating that the individual has low status for that micronutrient usually means that body stores or tissue levels are depleted and the individual is at greater risk of deficiency. This may reflect dietary inadequacy or health issues such as blood loss. However, a value indicating low status does not necessarily mean that the individual is clinically deficient, rather that they are at risk of becoming deficient.

[14] The RNI for a vitamin or mineral is the amount of the nutrient that is sufficient for about 97% 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 possible that some of the group will have an intake below their requirement.

[15] 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.

[16] Sadler K, Nicholson S, Steer T, Gill V, Bates B, Tipping S, Cox L, Lennox A and Prentice A (2012) Assessment of Dietary Sodium Levels Among Adults (aged 19-64) in England, 2011" [Online] Available: http://transparency.dh.gov.uk/2012/06/21/sodium-levels-among-adults/ (accessed 10/07/12).

[17] The Health Survey for England (HSE) is used to monitor “5-a-day”. HSE estimates of fruit and vegetable consumption are based on a recall of consumption over the previous 24 hours and are therefore different from NDNS estimates which are based on a four-day diary. NDNS estimates are higher than HSE estimates, at least in part because NDNS is better able to capture the contribution from composite dishes containing fruit and vegetables.

[18] For vitamin D, RNIs are only set for those aged up to 4 years and those aged 65 years and over.

[19] Vitamin A can be obtained in two forms: as preformed vitamin A (retinol) and from some carotenoids that can be cleaved in the body to provide retinol.

1. Background and purpose

Valdeep Gill

1.1. Introduction

The National Diet and Nutrition Survey (NDNS) is a survey of the food consumption, nutrient intakes and nutritional status of people aged 1.5 years and older living in private households. The survey is carried out in all four countries of the United Kingdom (UK) and is designed to be representative of the UK population. This report contains results for this core UK sample covering the first three years of the rolling programme 2008/09 to 2010/11. The report provides information about the diet and nutrient intakes of participants and includes results from analysis of blood samples.

Additional recruitment was undertaken in Scotland, Northern Ireland and Wales in order to achieve large enough samples in these countries to enable cross-country comparisons to be made.[1] These results will be reported at a later date when sufficient numbers are available for analysis.

The first four years of the NDNS rolling programme (2008/09 to 2011/12) were commissioned by the UK Food Standards Agency (FSA) in 2006 with a contribution to funding from the Department of Health (DH) in England. The contract was extended in 2011 for a fifth year of fieldwork (2012/13).

Responsibility for nutrition policy in England and in Wales transferred from FSA to Health Departments in 2010, but remains with FSA in Scotland and Northern Ireland. Management of the NDNS contract also transferred to DH at this time; the core UK survey continues to be jointly funded by DH and FSA, with the additional recruitment in Scotland, Wales and Northern Ireland funded by Government bodies in those countries.

The programme (for five years of data collection from 2008 to 2012/13) is carried out by a consortium of three organisations: the National Centre for Social Research (NatCen Social Research), MRC Human Nutrition Research (HNR), based in Cambridge and the Department of Epidemiology and Public Health at the Royal Free and University College London Medical School (UCL). Fieldwork in Northern Ireland

is carried out by the Northern Ireland Statistics and Research Agency (NISRA). Haematological and biochemical analyses of blood samples are carried out at HNR and Addenbrooke's Hospital NHS Trust, Cambridge.

This report presents findings from the first three years of the NDNS rolling programme, fieldwork for which was carried out between February 2008 and August 2011.[2] The three survey years have been combined to provide a larger sample size on which to base analyses. This first chapter provides an overview of the background and aims of NDNS. This is followed by information about the research designs and methodologies and response (chapter 2), socio-demographic characteristics of the sample (chapter 3) and physical measurements (chapter 4). Chapter 5 focuses on food consumption and nutrient intakes of participants and differences by age and sex and includes comparisons of intakes with government recommendations (Dietary Reference Values).[3] Chapter 6 provides results from analysis of blood samples for biochemical indices of nutritional status.

This report presents data for three years combined and highlights key findings, comparing them with government recommendations. Where the conclusions are unchanged from those reported in July 2011 for two years combined,[4] descriptive commentary has not been repeated.

Other elements of the first three years of the NDNS rolling programme (24-hour urine, total energy expenditure measured by doubly labelled water (DLW) and physical activity) will be included in future reports, when sufficient numbers permit meaningful analyses.

1.2. The National Diet and Nutrition Survey

Data from the NDNS is used for surveillance of the nutrient intake and nutritional status of the general UK population. The NDNS is the major component of the evidence base to support work by DH in England and other Government bodies across the UK to facilitate the adoption of healthier eating in order to improve the diet and nutrition of the UK population and reduce diet-related disease. The NDNS also provides detailed data on food consumption at the level of the individual which

enables FSA to carry out food chemical exposure assessments which form an essential part of their food safety risk assessments.

In the past, the NDNS programme comprised a series of cross-sectional surveys, each covering a different age group: pre-school children (aged 1.5 to 4.5 years);[5] young people (aged four to 18 years);[6] adults (aged 19 to 64 years);[7] and older adults (aged 65 and over).[8] The programme was set up in 1992 following the 1986/87 Dietary and Nutritional Survey of British Adults,[9] the first survey of this type in Britain. The first survey of the NDNS programme was carried out in 1992/93, and a survey was carried out about every three years thereafter until the NDNS of adults aged 19-64 years, carried out in 2000/01. Each was conducted as a stand-alone survey. Following a review of the dietary survey programme in 2003, FSA's Board agreed in principle that future surveys should be carried out on a rolling basis in order to strengthen the ability to track changes in diet and nutrition over time. The new rolling programme format of continuous fieldwork provides a more responsive framework for dietary surveys, giving more ability to identify emerging policy issues, responding more rapidly to changing data needs and giving better opportunities to identify and analyse trends. This will enable DH in England and other Government bodies across the UK to develop, implement and monitor effective policies to improve the nation's diet and nutritional status and will also support the FSA's risk assessment for food chemicals.

Prior to the launch of mainstage fieldwork in 2008, a comparison study of two different dietary assessment methods (randomly allocated to sampled addresses) was carried out in 2007. Over 1,100 adults and children took part with around half participating in interviewer-administered 24-hour dietary recalls (repeated on four non-consecutive days) and the others keeping a four-day estimated (unweighed) food diary on consecutive days. The NDNS Project Board considered the findings and decided that the four-day estimated diary (hereafter referred to as the "four-day food diary") should be used for the rolling programme.[10,11]

The specific aims of the NDNS rolling programme are to:

- provide quantitative data on the food and nutrient intakes, sources of nutrients and nutritional status of the UK population aged 1.5 years and above;

- provide information on trends in food consumption, nutrient intake and nutritional status in different age groups;
- describe the characteristics of individuals with intakes of specific nutrients above or below the national average;
- produce a database of food consumption which will be used to calculate intakes of natural toxicants, contaminants, additives and other food chemicals;
- measure blood and urine indices that provide evidence of nutritional status or dietary biomarkers, and to relate these to dietary, physiological and socio-demographic data;
- provide height, weight and other anthropometric measurements and examine their relationship to socio-demographic, dietary, biochemical and health data;
- monitor the diet of the population to establish the extent to which it is adequately nutritious and varied;
- monitor the extent to which the diets of population sub-groups vary from expert recommendations;
- assess total energy expenditure and physical activity levels and patterns in the study population; and
- provide information on oral health status in relation to diet and nutritional status.

The rolling programme will benefit a wide range of Government activities related to diet and health. It is key to monitoring progress on diet and nutrition objectives of UK Health Departments, for example those set out in the Healthy Lives Healthy People White Paper in England.[12] It will also provide the detailed food consumption data essential to support risk assessments for food chemicals.

As mentioned in section 1.1, this report includes combined results from Year 1 of NDNS (fieldwork carried out between February 2008 and June 2009), Year 2 (fieldwork carried out between April 2009 and August 2010) and Year 3 (fieldwork carried out between April 2010 and August 2011). A report on Year 1 of the survey was published on FSA's website in February 2010[13]; the main Year 1 and 2 combined data report was published on DH's website in July 2011[4] and a supplementary report on blood analytes was published in October 2011.[14] The results in this report supersede those presented in the earlier reports.

[1] Boosted samples in Scotland and Northern Ireland were included from Year 1. A boosted sample in Wales was included from Year 2 (starting April 2009).

[2] Fieldwork for Year 1 began in April 2008 and was completed in June 2009. It was preceded by a short run-in period from February to March 2009 to test procedures. Data from the run-in are included in the results. Fieldwork for Year 2 ran from April 2009 to August 2010. Fieldwork for Year 3 ran from April 2010 to August 2011.The fieldwork period was extended from Year 2 onwards to allow for a longer gap between the interviewer and nurse visits.

[3] Department of Health (1991). Dietary Reference Values for food Energy and Nutrients in the United Kingdom. (Report on Health and Social Subjects, No. 41). London: HMSO

[4] [Online]. Available: http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsStatistics/DH_128166 (Accessed 19/12/2011).

[5] Gregory JR, Collins DL, Davies PSW, Hughes JM, Clarke PC. National Diet and Nutrition Survey: children aged 1 ½ to 4 ½ years. Volume 1: Report of the diet and nutrition survey London: HMSO, 1995.
Hinds K, Gregory JR. National Diet and Nutrition Survey: children aged 1½ to 4½ years. Volume 2: Report of dental survey. London: HMSO, 1995.

[6] Gregory JR, Lowe S, Bates CJ, Prentice A, Jackson LV, Smithers G, Wenlock R, Farron H. National Diet and Nutrition Survey: young people aged 4 to 18 years. Volume 1: Report of the diet and nutrition survey. London: TSO, 2000.
Walker A, Gregory J, Bradnock G, Nunn J, & White D. National Diet and Nutrition Survey: young people aged 4 to 18 years. Volume 2: Report of the oral health survey. London: TSO, 2000.

[7] Henderson L, Gregory J, Swan G. National Diet and Nutrition Survey: adults aged 19 to 64 years. Volume 1: Types and quantities of food consumed. London: TSO, 2002.
Henderson L, Gregory J, Irving K, Swan G. National Diet and Nutrition Survey: adults aged 19 to 64 years. Volume 2: Energy, protein, carbohydrate, fat and alcohol intake. London: TSO, 2002.
Henderson L, Irving K, Gregory J, Bates CJ, Prentice A, Perks J, Swan G, Farron M. National Diet and Nutrition Survey: adults aged 19 to 64 years. Volume 3: Vitamin and mineral intake and urinary analytes. London: TSO, 2003.
Rustin D, Hoare J, Henderson L, Gregory J, Bates CJ, Prentice A, Birch M. National Diet and Nutrition Survey: adults aged 19 to 64 years. Volume 4: Nutritional status (anthropometry and blood analytes), blood pressure and physical activity. London: TSO, 2004
Hoare J, Henderson L, Bates CJ, Prentice A, Birch M, Swan G, Farron M. National Diet and Nutrition Survey: adults aged 19 to 64 years. Volume 5: Summary report. London: TSO, 2004.

[8] Finch S, Doyle W, Lowe C, Bates CJ, Prentice A, Smithers G, Clarke PC. National Diet and Nutrition Survey: people aged 65 years and over. Volume 1: Report of the diet and nutrition survey. London: TSO, 1998.
Steele JG, Sheiham A, Marcenes W, Walls AWG. National Diet and Nutrition Survey: people aged 65 years and over. Volume 2: Report of the oral health survey. London: TSO, 1998.

[9] Gregory J, Foster K, Tyler H, Wiseman H. The Dietary and Nutritional Survey of British Adults. London: HMSO, 1990.

[10] Following considerable discussion of the dietary assessment method to use for the rolling programme, it was decided to conduct a study to compare the two possible methods that might be adopted, a repeat 24-hour recall method and an estimated (unweighed) diary. The results of the comparison study showed equivalent response rates, comparable experiences for interviewers and participants, similar energy and nutrient intakes and similar extent of misreporting by the two dietary assessment methods compared. However, there were a number of considerations that leaned

towards the estimated diary for the survey on an ongoing basis, not least continuity with past NDNS surveys and flexibility with a wide range of age groups.

[11] Stephen A, Teucher B, Bluck L, Cole D, Fitt E, Mander A, Woodward R, Wright A, Bates B, Roberts C, Mackenzie H, Deverill C, Mindell J. National Diet and Nutrition Survey Rolling Programme, Comparison Study, Part 1. A comparison of results by dietary assessment method: repeat 24-hour recall and four-day estimated (unweighed) diet diary. Unpublished. 2008.

[12] Department of Health Healthy Lives, Healthy People: Our strategy for public health in England White paper [Online] Available http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_121941 (accessed 19/12/2011)

[13] [Online]. Available: http://www.food.gov.uk/science/dietarysurveys/ndnsdocuments/ndns0809year1 (Accessed 19/12/2011)

[14] http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsStatistics/DH_130728 (Accessed 19/12/2011)

2 Methodology and response

Rosie Sutton

2.1 Overview of methodology

This chapter provides an overview of Year 3 methodology. Information about methodology for Years 1 and 2 can be found in chapter 2 of the previous reports.[1,2] There were very few methodological differences between Year 3 and previous years; the key differences are provided in section 2.7.

In order to meet the aims of the survey (see section 1.2) a sample of people representative of the UK population aged 1.5 years and over was required. This sample was drawn from the Postcode Address File (PAF),[3] a list of all the addresses in the UK. In order to improve cost effectiveness the addresses were clustered into Primary Sampling Units (PSUs), small geographical areas, based on postcode sectors, randomly selected from across the UK. A list of addresses was randomly selected from each PSU.

Information describing the purpose of the survey was posted to all selected addresses. This was followed by a face-to-face visit by an interviewer to each address to recruit participants in the eligible age range(s). As in Years 1 and 2, the survey aimed to collect data from a UK representative core sample of 1,000 people per year, 500 adults (aged 19 years and over) and 500 children (aged 1.5 to 18 years). In order to achieve (as far as possible) equal numbers of adults and children in the sample, at some addresses only children were selected to take part (see section 2.2.2). In addition extra addresses were selected in Wales, Scotland and Northern Ireland to boost the sample size in these countries and enable comparisons to be made between the UK countries.[4]

At each address, the interviewer enumerated the number of households and, in cases where there were two or more, randomly selected one for NDNS. From each selected household an interviewer randomly selected up to one adult and one child to take part in the survey. These are known as *participants*. The first stage of the survey comprised a face-to-face Computer Assisted Personal Interview (CAPI) with

each participant (or in the case of a young child, their parent or guardian[5]), completion of a four-day food diary by the participant (outside the interviewer visits) and measurements of height and weight. The interviewer also collected information on shopping and food preparation practices and facilities in the household by additionally interviewing the *Main Food Provider* (MFP)[6] of the household where this was not a selected participant. The MFP was the person who was best placed to answer questions about food purchased and prepared for the participant(s). The interview also identified the *Household Reference Person* (HRP)[7] in each household and asked questions about housing tenure, as well as his or her employment, to determine the socio-economic classification of the household.[8]

Participants who took part in the CAPI interview and completed a food diary for at least three days were classified as '*fully productive'* and were invited to take part in the second stage of the survey. This involved a visit from a nurse to take physical measurements, a blood sample and a 24-hour urine collection. In addition, a sub-sample of participants were recruited for a Doubly Labelled Water (DLW) sub-study to measure energy expenditure.

2.2 Sample design

2.2.1 Selecting addresses

The Year 3 sample was drawn from the PAF. A core UK sample of 3,240 addresses was selected from 120 PSUs. Twenty seven addresses were randomly selected in each selected PSU. At each address, the interviewer established the number of households and, in cases where there were two or more, selected one household at random.

2.2.2 Selecting participants

The 27 addresses were randomly allocated to one of two groups to determine whether an adult (aged 19 years or over) and a child (aged 1.5 to 18 years), or a child only, were selected for interview. At nine of the selected addresses the interviewer selected one adult and, where present, one child for inclusion in the survey. The remaining 18 addresses were for a "child boost" and the interviewer only carried out interviews in households with children. In households containing more

than one eligible person (adult and/or child), interviewers selected the participant(s) using a random selection procedure.

Further details on sampling can be found in Appendix B.

2.3 Ethical approval

Ethical approval for the study was obtained from the Oxfordshire A Research Ethics Committee. The letters of approval for the original submission and subsequent substantial amendments, together with approved documents, were sent to all Local Research Ethics Committees (LRECs) covering areas where fieldwork was being conducted. Research governance[9] approval was sought for all participating NHS laboratories and obtained where required by the Research and Development (R&D) Committee.

2.4 Fieldwork

Year 3 fieldwork was issued monthly to interviewers and nurses in the following waves:

	Interviewers (Stage 1)	*Nurses (Stage 2)*
Quarter 1	April-June 2010	July-September 2010
Quarter 2	July-September 2010	October-December 2010
Quarter 3	October-December 2010	January-March 2011
Quarter 4	January-March 2011	April-June 2011

Stage 1 fieldwork commenced on the first weekday of the month, and interviewers were given six weeks in which to complete their assignment. Stage 2 fieldwork for a particular month started six weeks after the interviewer deadline (for example, interviewers completed April assignments by mid-May 2010 and nurse visits to these participants started in July 2010). Nurses had up to seven weeks to complete their work.

2.5 Overview of survey components and fieldwork procedures

There were two main stages to the survey:

Stage 1: Interviewer visit:	Four-day food diary
	Detailed background interview
	Interview with MFP
	Height and weight measurements
	Smoking and drinking self-completion questionnaires
	Physical activity self-completion questionnaire or ActiGraph
	DLW sub study
Stage 2: Nurse visit:	Blood sample
	24-hour urine collection
	Physical measurements
	Blood pressure
	Collection of information about prescribed medicines

2.5.1 Stage 1: the interviewer visits

A letter and leaflet describing the purpose of the survey was sent to all sampled addresses before the fieldwork start date. A few days later, interviewers visited the addresses to determine whether the address was private, residential and occupied. They then carried out the selection process and, for children aged under 16 years, sought both the child's and their parent's (or guardian's) consent to interview.

Interviewers carried out three main visits to households who agreed to participate:

- **Visit 1:** Four-day food diary explained to the participant and left with them to complete; interviewer-administered CAPI; height and weight measurements; and self-completion booklets in which children and young people are asked to record their smoking and drinking habits. Participants aged 16 years and above were asked to complete a self-completion questionnaire designed to collect information about physical activity (the Recent Physical Activity Questionnaire (RPAQ)).[10] Children aged 4 to 15 years were asked whether

they would be willing to wear a physical activity monitor (an ActiGraph) for seven consecutive days (the monitor was explained and left with those who agreed to wear it).

- **Visit 2:** The diary check up visit, where the interviewer reviewed the completion of the four-day food diary so far and filled in any missing information with the participant.
- **Visit 3:** Review and collection of four-day food diary, RPAQ self-completion and ActiGraph and further CAPI questionnaire administration.

At the end of the third main interviewer visit, interviewers gave each participant completing at least three food diary recording days a token of appreciation (£30 in high street vouchers).[11] Interviewers then introduced the second stage of the survey, asking for permission for the nurse to visit. In addition, a sub-sample of participants were recruited for a Doubly Labelled Water (DLW) sub-study to measure energy expenditure.

Further details about information collected during the interviewer stage (and the fieldwork documents used) can be found in Appendices C to F.

2.5.1.1 Computer Assisted Personal Interview (CAPI) programme

CAPI interviewing involves the interviewer reading questions from a laptop screen and entering the participants' responses into designated fields. The CAPI questionnaire had three main elements: household composition/ structure interview, MFP interview and individual interview. The individual questionnaire, asked of each selected participant had two parts: Part 1, which was asked at the first main interviewer visit; and Part 2, which was asked at the third main visit after the interviewer collected the food diary.

The content of the CAPI questionnaires is shown in Appendix D.

2.5.1.2 Collection of dietary data: the four-day food diary

Based on the day of the first individual CAPI interview, the interviewer's laptop program selected four consecutive days as the food diary recording period.

Participants were provided with a diary and asked to keep a record of everything they ate and drank over these four days, both in and outside the home. Interviewers carried out a food diary check visit with participants on the second or third day of recording either in person or over the telephone, with the aim of improving recording for the remaining days and also providing encouragement to participants to continue recording. Interviewers then returned to collect the diary and check the remaining days no later than three days after the final day of recording.

As participants were not expected to weigh their food and drink, portion sizes were estimated using household measures (e.g. two thick slices of bread, four tablespoons of peas) or using weights from labels (e.g. 420g tin of baked beans, 330ml can of lemonade). Those aged 16 years and over were also able to describe their portion size using photographs of 10 frequently consumed foods reproduced in the diary.

A parent was asked to keep the food diary on behalf of participants aged 11 years and younger, with the child contributing information where possible and with help from other carers.

In quarter 2 of Year 3, a pilot was carried out to assess the feasibility of using photograph atlases as a tool for estimating portion sizes in children. The pilot showed the atlases to be a valuable tool in improving the accuracy of portion sizes in NDNS and they were rolled out in Year 4. Further information is provided in Appendix A of this report.

Appendix A provides full details of the dietary data collection and processing protocols.

2.5.1.3 Selection of food diary start day

The study design for Year 3 aimed to give an even representation of diary days on all days of the week so the food diary could start on any day of the week and run for four consecutive days. The diary start day for each participant was assigned by the CAPI program but could be changed by the interviewer if the participant preferred a different day.

In Year 1, the recording period always started on a Thursday, Friday or Saturday and included both weekend days (Saturday and Sunday). This meant that weekend days were over-represented and Wednesdays were never represented. To redress the over-representation of weekend days and non-representation of Wednesdays in Year 1, the food diary recording period was changed from Year 2 onwards so that all days of the week would (as far as possible) be equally represented.

Further information about the food diary can be found in chapter 5, section 5.1.

2.5.2 Stage 2: the nurse visits

Stage 2 of the survey was carried out by a qualified nurse and took place within two to four months of the final interviewer visit. All individuals completing three or four food diary days were eligible for a nurse visit.

At the end of Stage 1, interviewers provided participants with information leaflets giving details of the nurse visit. Nurses could provide these again if necessary. The nurse asked questions about prescribed medications before taking, with agreement, a number of physical measurements.

2.5.2.1 Measurements taken by the nurse

A summary of the information collected during the nurse stage is provided below. Some of the information collected by nurses was limited to particular age groups.

Measurement or procedure	**Participant**
Details of prescribed medications	All ages
Blood pressure	Aged four years and over
Infant length measurement	Aged 18 to 23 months
Waist and hip circumferences	Aged 11 years and over
Demispan	Aged 65 years and over and those aged 16 to 64 years where height could not be measured
Mid Upper Arm Circumference (MUAC)	Aged 2 to 15 years

24-hour urine collection	Aged four years and over fully out of nappies
Non-fasting blood sampling	Aged 1.5 to 3 years and diabetics not willing to fast
Fasting blood sampling	Aged four years and over

The nurse fieldwork documents are provided in Appendices G and H. Measurement protocols are provided in Appendix I.

2.5.2.2 Blood sampling

After providing the physical measurements, participants were asked whether they were willing to give a small blood sample by venepuncture after an overnight fast (those aged 1.5 to 3 years and diabetics not willing to fast were asked whether they were willing to provide a non-fasting blood sample). The nurse obtained written consent from the participants aged 16 years and over before the sample was taken. For children aged 1.5 to 15 years, written consent of a parent or guardian was required and nurses additionally obtained the assent of the child where possible. For those aged 10 years or younger, blood was taken by a paediatric phlebotomist who accompanied the nurse on the visit. Nurses also sought written agreement to store part of the blood sample for additional analyses at a future date. Participants who provided a blood sample were given £15 in high street vouchers as a token of appreciation for agreeing to this part of the study.

2.5.2.3 24-hour urine sampling

Nurses also sought agreement from adult participants, and child participants aged four years and over who were fully out of nappies (and their parent or guardian), to provide a 24-hour urine collection. If participants agreed, they were asked to take three para-aminobenzoic acid (PABA) tablets evenly spaced throughout the waking hours of the day on which the 24-hour urine sample was collected, in order to assess the completeness of the urine collections.

Written consent was sought for the taking of PABA tablets, laboratory analysis of the 24-hour urine sample and storage of any remaining urine for future analyses.

Participants who provided a 24-hour urine sample were given £10 in high street vouchers as a token of appreciation for taking part in this element of the study.

2.5.3 Feedback to participants and GPs

Participants who completed three or four food diary recording days were asked whether they would like to be sent feedback on the analysis of their diary and how this compared to nutrient intake recommendations. The feedback also included general information on sources of healthy eating advice. Further information about the dietary feedback can be found in Appendix A and an example of the dietary feedback is provided in Appendix J.

Each participant was also given a 'Measurement Record Card' on which the interviewer and nurse recorded the person's height, weight, body mass index (BMI) (if aged 16 years and over), blood pressure (if aged four years and over) and other age-dependent anthropometric measurements (waist and hip circumferences (ages 11 years and over); mid upper arm circumference (MUAC) (aged two to 15 years); demispan measurement (aged 65 years and over) and infant length (aged 18 to 23 months). Participants who provided a blood sample were additionally asked whether they wished to be sent results of the blood sample analyses most related to their health. Participants were asked if they wanted details of these analyses, their BMI and their blood pressure readings to be sent to their GP. If they did, written consent was obtained from the individual (or from the parent in the case of a child). See Appendix J for an example of feedback to GPs.

2.6 Fieldwork quality control

2.6.1 Project specific training for interviewers and nurses

Fieldwork in England, Scotland and Wales was carried out by NatCen Social Research's panel of interviewers and nurses. In Northern Ireland, fieldwork was carried out by interviewers and nurses working for NISRA.

All interviewers and nurses working on NDNS were briefed and trained before undertaking an assignment and were monitored during their assignment.

Fieldworkers were also issued with comprehensive written instructions covering survey procedures and measurement protocols.

2.6.2 Training for interviewers

All new-to-NDNS interviewers (and those who had worked in Year 1 but not in Year 2) attended a two-day training course where they were fully briefed on the protocols and administration of the survey. Interviewers who had previously worked in Year 2 of NDNS attended a one-day refresher briefing.

The full and refresher briefing sessions covered background and content, doorstep approach, questionnaire administration (including practice sessions), placement and collection of self-completions and ActiGraphs, the DLW procedure and the placement, checking and collection of the four-day food diaries. Interviewers at the two-day briefings were also trained in taking height and weight measurements.

After the briefing, “early work” checks were carried out on the first two or three food diaries returned by each interviewer with timely feedback provided on any areas of concern. All interviewers working on a second or subsequent assignment received feedback on the diaries from their previous assignment. Further, any interviewer who had more than three months gap between assignments completed their own two-day diary which was reviewed and comments fed back.

2.6.3 Training for nurses

Nurse briefings lasted one and a half days and covered equipment training, blood sampling and 24-hour urine training and questionnaire administration (including practice sessions). Most nurses who worked on NDNS were very experienced in taking all the physical measurements collected on the study. Any newer nurses also attended a general NatCen Social Research nurse training session which covered standard protocols for all physical measurements.

2.7 Key methodological changes between Years 2 and 3

A number of methodological changes were introduced in Year 3 of NDNS. These are summarised below:

- The DLW sub-study takes place in alternate fieldwork years (i.e. Years 1 and 3) and so was reinstated in Year 3.
- The study design for Year 3 aimed to give an even representation of diary days on all days of the week; the food diary could therefore start on any day of the week.
- Young persons' photo food atlases were trialled in Quarter 2 of Year 3 to test the feasibility of their use in Year 4. The young persons' photo food atlases were intended as a tool to improve the accuracy of portion sizes for participants aged under 16 years (see Appendix A for further information).
- A question was introduced in the CAPI interview to find out whether households were in receipt of Working Families' Tax Credits, Income Support or Income-Related Job Seekers Allowance.

These methodological changes do not affect the way the rest of data is collected, analysed nor interpreted.

2.8 Response rates

Response rates presented in this section are for Years 1, 2 and 3 combined.[12]

2.8.1 Household level response

Overall for Years 1, 2 and 3 combined, of the 9,990 addresses issued to interviewers, 46% were eligible for household selection and 54% were ineligible. Ineligible addresses include vacant or derelict properties/institutions. Child boost addresses that were screened out were also included in the ineligible category, which explains the higher than average proportion of ineligible addresses.

Household selection was carried out at 91% of eligible addresses. The remaining 9% of addresses refused before the household selection could be carried out. Of those selected households, 62% were productive – i.e. at least one selected participant completed three or four dietary recording days.

(Table 2.1)

2.8.2 Individual level response

The overall response rate for fully productive individuals (i.e. those completing three or four dietary recording days) was 55% in Year 1, 55% in Year 2 and 52% in Year 3, giving a sample size of 3,073 fully productive individuals.[13] Analyses in this report (including response rates for subsequent stages/components of the survey) are based on these 3,073 individuals.

Valid height and weight measurements were obtained for almost all fully productive participants (height 95%; weight 94%).

Seventy five per cent of all fully productive participants were visited by a nurse.[14] Physical measurements including waist and hip circumference, MUAC and blood pressure were taken from about 74% of fully productive participants (adults and children) by a nurse.

Fifty per cent of adults completing at least three diary days and 27% of children completing at least three diary days provided a blood sample. Younger children were less likely to give a blood sample than older children or adults: 19% of those aged 1.5 to 10 years provided a blood sample compared with 38% of those aged 11 to 18 years and 50% of those aged 19 years and over.

Fifty nine per cent of participants aged four years and over and who completed at least three diary days provided a 24-hour urine collection for analysis.
(Table 2.2)

2.9 Weighting the survey data

It is necessary to apply weighting factors to the data collected in NDNS for two reasons: to remove any bias in the observed results which may be due to differences in the probability of households and individuals being selected to take part; and to attempt to reduce non-response bias.

The survey was designed so that no more than one adult and one child were selected from any one household to take part. This meant that adults living in households with one or more other adults, and children in households with one or

more other child were less likely to be selected than were adults or children in single adult/child households.

In addition, the multi-stage design means there were a number of stages in the survey where it was possible for participants to drop out. If the people who refused to participate at a particular stage were systematically different from those who took part then the sample would be biased.

Weighting factors were used to correct for both these cases. There were two stages to the weighting scheme: the first was to generate a set of design weights to correct for the unequal selection probabilities; and the second was to create a set of weights to adjust for non-response. The final weights were a product of the selection weights and the non-response weights. Full detail of the NDNS weighting scheme is provided in Appendix B.

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[1] [Online]. Available: http://tna.europarchive.org/20110116113217/tna.europarchive.org/20110116113217/http://www.food.gov.uk/science/dietarysurveys/ndnsdocuments/ndns0809year1 (accessed 08/01/12).

[2] [Online]. Available: http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsStatistics/DH_128166 (accessed 21/11/11).

[3] The sample was drawn from the 'small users' sub-file of the Postcode Address File (PAF) is a computer list, prepared by the Post Office, of all the addresses (delivery points) which receive fewer than 25 articles of mail a day.

[4] These results will be published at a later date when sufficient numbers are available for analysis.

[5] A guardian is defined as a person with legal responsibility for the child.

[6] The Main Food Provider (MFP) is the person in the household with the main responsibility for shopping and preparing food. If these tasks are shared equally between two people, for example if one person does all the shopping and another person does all the cooking, then either resident could be classified as the MFP.

[7] 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.

[8] Questions were asked to ascertain whether the HRP was in paid work at the time of the interview and, if not, whether they had ever had a paid job. If the HRP had ever worked, there were further questions about their current or most recent job in order to classify HRPs into the National Statistics Socio-economic Classification (NS-SEC) groupings.

[9] The Research Governance Framework is intended to define the broad principles of good research practice, and to ensure that health and social care research is conducted to high scientific and ethical standards.

[10] Based on the Recent Physical Activity Questionnaire developed by the MRC Epidemiology Unit, Cambridge.

[11] Children who had worn an ActiGraph were given a promissory note stating that their £10 token of appreciation would be sent from the office within four weeks of interview.

[12] Response rates for Years 1 and 2 were very similar but Year 3 response was slightly lower.

[13] A further 133 individuals completed one or two diary days or refused before or during the CAPI interview. Of the 3,073 fully productive individuals, 3,020 (98%) completed four dietary days and 53 (2%) completed three days.

[14] 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.

3. Socio-demographic characteristics of the NDNS sample

Katharine Sadler

3.1. Introduction

This chapter provides data on the socio-demographic and health-related lifestyle characteristics of the NDNS sample for Years 1, 2 and 3 combined, using data collected during the CAPI interviews and additionally from self-completion questionnaires in the case of smoking and drinking analysis.

Tables 3.1-3.3 show the sex and age distribution of the NDNS sample and how this was weighted to bring it into line with the UK general population.

All text and tables in the remainder of the report use data weighted to reflect the sex and age profile of the UK general population.[1] Table 3.4 shows the socio-economic breakdown of the sample based on the employment of the Household Reference Person for each household. Table 3.5 shows the breakdown by age of leaving education and highest qualification attained. Table 3.6 shows the proportion of the sample who reported following a vegetarian or vegan diet. Tables 3.7-3.9 show the reported smoking behaviour of the sample and Tables 3.10-3.13 show the drinking behaviour of the sample. Recommendations on alcohol consumption are explained in the following sections. The characteristics of the NDNS sample for years 1-3 combined are very similar to those for years 1-2 and are in line with the general population where statistics are available.

(Tables 3.1 – 3.13)

3.2. Information to aid interpretation of findings on alcohol consumption

3.2.1 Drinking behaviour amongst adults aged 16 years and older

The recommended sensible drinking guidelines for England, Wales, Scotland and Northern Ireland are that men should not regularly drink more than three to four units of alcohol per day, and women should not regularly drink more than two to three units of alcohol per day. Men who regularly drink more than eight units a day (or 50

units a week) and women who regularly drink more than six units a day (or 35 units a week) are considered to be at particular risk of harm.[2,3]

Alcohol consumption is reported in terms of units of alcohol; one unit of alcohol is 10ml by volume of pure alcohol. Daily consumption is calculated by recording the amounts drunk on the day in the past week when the participant drank most.[4]

3.2.2 Drinking behaviour amongst children aged 8 to 15 years

In 2009, the Department of Health published guidance written by the Chief Medical Officer on the consumption of alcohol amongst children and young people.[5] The guidance makes clear that an alcohol-free childhood is the healthiest option. The guidance also recommends that parents should try to ensure that their children do not drink alcohol, at least up to the age of 15 years. Furthermore, it advises that young people aged 15 to 17 years should never exceed recommended adult daily limits and, on days when they drink, consumption should be below such levels. Advice in Scotland is that not drinking alcohol at all is the best option for young people.[6]

As discussed in the 'Smoking, drinking and drug use among young people in England in 2010' report, [7] attempting to accurately measure alcohol consumption among children can be challenging. Recall of their drinking can be erroneous; a generally acknowledged problem for all surveys measuring alcohol consumption. Second, the majority of children's' drinking is in informal settings, and the quantities they drink are not necessarily standard measures. This should be borne in mind when interpreting the figures in tables 3.12 and 3.13.

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[1] Office for National Statistics. *Mid 2010 Population Estimates.* Available: www.statistics.gov.uk/statbase/Product.asp?vlnk=15106 (accessed 12/12/11).

[2] Department of Health (2007). Available: http://www.dh.gov.uk/en/Publichealth/Alcoholmisuse/DH_125368 (accessed 14/12/11). Drinking at this level has been described in surveys, including the Health Survey for England, as 'binge drinking'. 'Binge drinking' is also used to define a pattern of drinking a large quantity of alcohol in a short period with the aim of getting drunk. In practice, this may involve considerably more than twice the recommended daily limits. To avoid confusion, the term 'binge drinking' is not used in this report.

[3] http://wales.gov.uk/docs/phhs/publications/100723cmoalcposen.pdf

[4] Adults (i.e. those aged 16 years or older) who drank bottled or canned beer, lager, stout or cider were asked in detail about what they drank, and this information was used to estimate the amount in pints (one pint is equivalent to 0.568 litres). Adults were also asked to quantity the amount of wine drunk in terms of large (250ml), standard (175ml) and small (125ml) glasses, and were also given the option of specifying the quantity of wine drunk in bottles or fractions of a bottle; a bottle was treated as the equivalent of six small (125ml) glasses. Adults who drank spirits were asked to quantify how much they drunk in single measures (25ml).

[5] Department of Health. Guidance on the consumption of alcohol by children and young people. A report by the Chief Medical Office. DH, London, 2009. http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/documents/digitalasset/dh_110256.pdf (accessed 02/04/12).

[6] http://www.drinksmarter.org/sensible-drinking-and-you/alcohol-and-young-people (accessed 20/02/12).

[7] http://www.ic.nhs.uk/webfiles/publications/003_Health_Lifestyles/Smoking%20drinking%20drug%20use%202010/Smoking_drinking_and_drug_use_among_young_people_in_England_2010_Full_report.pdf (accessed 29/06/12).

4 Physical measurements

Alison Moody

4.1 Introduction

This chapter presents physical measurements taken during Stage 1 (the interviewer visit): height and weight, from which body mass index (BMI) was calculated and Stage 2 (the nurse visit): waist and hip circumferences; and blood pressure. Comparisons are made, where possible, with data on physical measurements from the most recent health surveys in England, Scotland and Wales.[1, 2, 3] Data presented are for Years 1, 2, and 3 combined.

Detailed descriptions of the measurement protocols used on NDNS are available in Appendix I but a brief description is provided within each section below.

Other physical measurements taken during the nurse visit (mid upper arm circumference (MUAC)) are not reported in this chapter but will be included in the archived data (see Appendix Q for more detail).

4.2 Anthropometry

4.2.1 Measurements

Height and weight were measured at the first interviewer visit, 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 (m^2)) was calculated by the interviewer's CAPI program. For participants whose height could not be measured, estimated height based on demispan[4] was used to calculate BMI.[5] For children aged 1.5 to two years, the interviewer measured length instead of height. Length has been used in place of height when calculating BMI for these youngest children. The nurse measured waist and hip circumferences in those aged 11 years and over using a tape measure.[6]

4.2.2 Obesity

4.2.2.1 Adults

Table 4.1a shows mean BMI and BMI status, in adults, by age group and sex (according to the World Health Organisation (WHO)[7] and National Institute for Health and Clinical Excellence (NICE) classification[8] as shown in Table 4A below):

Table 4A: BMI classification

BMI (kg/m^2)	**Description**
Less than18.5	Underweight
18.5 to less than 25	Normal
25 to less than 30	Overweight
30 or more	Obese
40 or more	Morbidly obese

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 (WHR) was raised (greater than 0.95 for men and greater than 0.85 for women).

. **(Table 4.1a)**

4.2.2.2 Children

New UK World Health Organisation (WHO) growth charts for children from birth to four years were introduced for all new births in England, Wales and Northern Ireland from May 2009 and in Scotland from January 2010.[9] These are based on WHO Growth Standards from data in infants who were exclusively or predominantly breastfed.[10, 11]

Growth standards for the youngest children 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).

For clinical purposes, the 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.[12] BMI results in children must be interpreted carefully. Results are useful as an indicator of over-or under-nutrition, provided they are compared with suitable age- and sex-specific thresholds for defining normal / abnormal categories.[13]

(Table 4.1b)

4.2.2.3 Comparisons with other surveys

Comparisons of results for adults participating in NDNS with adults measured recently in England and Scotland[14] showed that anthropometric measurements were broadly similar between NDNS, Scottish Health Survey 2010 (SHeS 2010[1]) and the Health Survey for England 2010 (HSE 2010[2]) for both sexes.

In order to compare the NDNS estimates with the other surveys, this paragraph refers to children aged 2 to 15 years only; the estimates therefore differ from those shown for children aged 2 to18 years in Table 4.1b. When comparing children's anthropometric results for NDNS with the other surveys, analyses in the NDNS were not entirely comparable with HSE, SHeS or Welsh Health Survey (WHS)[15] due to the smaller age bands and different reference thresholds for obesity being used for children aged two to three years in the different surveys. The proportion of boys who were overweight or obese appeared to be lower in NDNS (18% obese) than in WHS (23%). The proportion of girls who were overweight or who were obese appeared to be higher in NDNS than in SHeS 2010 (19% obese in NDNS, 13% in SHeS 2010,) and slightly higher than in HSE 2010 (15%). It should be noted that these comparisons were not formally tested.

4.3 Blood pressure

4.3.1 Measurement of blood pressure

Blood pressure was measured in a sitting position using an automated, validated machine, the Omron HEM907, after a five minute rest. Results presented in this chapter are based on the mean of the second and third readings, taken at one minute intervals, in participants with valid readings, who had not eaten, drunk alcohol, exercised, or smoked in the preceding 30 minutes. Full details of protocols are available in Appendix I.

Hypertension was defined as a systolic blood pressure of 140mmHg or above, and/or diastolic blood pressure of 90mmHg or above,[16] and/or taking medication specifically to reduce blood pressure.

4.3.2 Results

Table 4.2 shows means systolic (SBP) and diastolic (DBP) blood pressure by age and sex, together with the proportion of participants whose blood pressure results indicated hypertension, and whether this was treated and/or controlled.

(Table 4.2)

4.3.3 Comparisons with other surveys[3]

The proportion of participants in NDNS with survey-defined hypertension was in line with the proportion in England in HSE 2010.[2] Blood pressure was not measured in the WHS, and was not reported in HSE 2010 nor in SHeS 2010.[1]

References and endnotes

[1] Bromley C, Given L, (eds.) *The Scottish Health Survey 2010.* Edinburgh: Scottish Executive, 2011.

[2] Craig R, Mindell J. (eds). *Health Survey for England 2010.* Leeds: The NHS Information Centre, 2011

[3] Comparisons of NDNS with health surveys in Northern Ireland could not be made, and for Wales could only be made for children due to the data not being comparable or available. The most recent Northern Ireland survey (carried out in 2005/06) did not include a measurement module. The Welsh Health Survey uses self-report, not measured weight and height for adults.

[4] 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 BMI in older people. (Hirani V, Mindell J. *A comparison of measured height and demispan equivalent height in the assessment of body mass index among people aged 65 years and over in England*. Age Ageing. 2008;37:311-7.)

[5] The demispan equivalent height was calculated using regression equations derived by Bassey: (Bassey EJ. *Demispan as a measure of skeletal size*. Annals of Human Biology 1986; 13: 499-502.)
Females: Height (cm) = (1.35x demispan in cm) + 60.1
Males: Height in (cm) = (1.40x demispan in cm) + 57.8.

[6] 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 two closest measurements was used. If only one measurement was available, it was excluded from the analysis.

[7] *World Health Organisation body mass index (BMI) classification*. [On-line] www.who.int/bmi/index.jsp?introPage=intro_3.html (accessed 21/12/2011).

[8] National Institute of Health and Clinical Excellence. *Obesity: the prevention, identification, assessment and management of overweight and obesity in adults and children.* [On-line] www.nice.org.uk/guidance/index.jsp?action=download&o=38295. page 221 (accessed 21/12/2011).

[9] SACN/RCPCH. Application of WHO Growth standards in the UK London: TSO, 2007. www.sacn.gov.uk/pdfs/sacn.rcpch_who_growth_standards_report_final.pdf (accessed 29/03/2012)

[10] Royal College of Paediatrics and Child Health / World Health Organisation. *The UK_WHO Growth Charts: Early Years.* London: RCPCH, 2009. www.rcpch.ac.uk/Research/UK-WHO-Growth-Charts (accessed 21/12/2011).

[11] 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 two weeks to four 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 four years and over.

[12] Cole T, Freeman JV, Preece MA. *Body mass index reference curves for the UK, 1990.* Arch Dis Child 1995; 73: 25-29.

[13] Scientific Advisory Committee on Nutrition and Royal College of Paediatrics and Child Health. Consideration of issues around the use of BMI centile thresholds for defining underweight, overweight and obesity in children aged 2-18 years in the UK. April 2012. Online at: http://www.sacn.gov.uk/reports_position_statements/position_statements/sacnrcpch_joint_statement_on_defining_child_underweight_overweight_and_obesity_in_the_uk_-_april_2012.html (Accessed 04/07/12)

[14] The age at which a participant is defined as an adult is slightly different between the surveys: in the NDNS participants aged 19 years and over are classed as adults whereas for HSE and SHeS, those aged 16 years and over are defined as adults. In the results, 'younger' means from that minimum age up to 64 years.

[15] Walters L, Kingdon A, Roberts C (eds.). *Welsh Health Survey 2010.* Welsh Assembly Government 2011. [On-line] http://wales.gov.uk/topics/statistics/publications/healthsurvey2010/?lang=en (accessed 07/12/2011)

[16] Hypertension was defined as over 140/90mmHg in the following paper:
Williams B, Poulter NR, Brown MJ et al. *Guidelines for management of hypertension: report of the fourth working party of the British Hypertension Society, 2004 –BHS IV.* J Hum Hypertens. 2004; 18:139-85.
These thresholds were reiterated in the latest NICE guidelines, which also recommend ambulatory blood pressure monitoring to confirm a diagnosis of hypertension if the clinic measurement indicates blood pressure over the over 140/90mmHg threshold. http://publications.nice.org.uk/hypertension-cg127/key-priorities-for-implementation#diagnosing-hypertension Within the constraints of the survey, blood pressure was measured three times, and the average of the second and third readings used for analysis.

5. Dietary intakes

Caireen Roberts, Sonja Nicholson, Toni Steer and Alison Lennox

5.1 Introduction

The results presented in this chapter derive from Years 1, 2 and 3 combined of the NDNS rolling programme. Dietary data were collected between February 2008 and April 2011, with a core UK sample of 3073 individuals aged 1.5 years and over. The results supersede those reported for previous years of the NDNS rolling programme.[1,2] No comparisons have been made between individual years of the survey because of small numbers in each year. Results are presented for both sexes combined for the age groups: 1.5 to 3 years, 4 to 10 years, 11 to 18 years, 19 to 64 years and 65 years and over. For those aged 1.5 to 3 years and 65 years and over, numbers are small and this should be taken into account when reviewing the data for these age groups. Results are also subdivided by sex for all age groups, except for children aged 1.5 to 3 years as intakes in this age group do not tend to vary by sex. Unless stated otherwise, all Dietary Reference Values (DRVs) discussed in Chapter 5 are those presented in the 1991 COMA report on Dietary Reference Values for Food Energy and Nutrients for the United Kingdom.[3]

Results are based on dietary assessment using a four-day food diary and represent a daily average of the days assessed. In Year 1 the study design was to have each participant record both weekend days, in an effort to capture both weekday and weekend consumption for each person. It was thought that the oversampling of weekend days in Year 1 could have led to a bias in reported food consumption and nutrient intake, since it has been shown that there is day-to-day variation in intake of some foods and nutrients for specific age and sex groups. For example, men often consumed alcoholic beverages and takeaway foods more frequently on Fridays and Saturdays, whilst Sunday is often associated with higher consumption of meat and vegetables in many groups. Hence from Year 2 onwards, the design was changed to one where all days of the week would (as far as possible) be equally represented. Year 2 was therefore designed to over-represent weekdays and under-represent weekend days (see section 2.5.1.3 for more detail). Year 3 was designed so that all days of the week were evenly represented. However, in the Years 1, 2 and 3

combined data, there remains a slightly higher proportion of weekend days than weekdays (see Table 5A below). This may be explained by the survey design allowing some flexibility in the diary start day.

Table 5A: Number of diary days by day of week (Years 1-3 combined)

Day of the week	Number of diary days
Monday	1,653
Tuesday	1,484
Wednesday	1,400
Thursday	1,701
Friday	1,965
Saturday	2,026
Sunday	2,010

Misreporting of food consumption, generally under-reporting, is known to be an issue in NDNS as in all dietary surveys. The degree of under-reporting needs to be borne in mind when interpreting findings from this survey. The doubly labelled water (DLW) technique has been used to measure total energy expenditure in a sub-sample of NDNS participants to assess the extent of misreporting of energy intake.[4] Results of the DLW analyses will be published at a later date. Results from the existing literature suggest that some foods and nutrients may be under-reported to a greater extent than others, and some may be over-reported, but there is no information available on the degree to which different foods and nutrients are misreported in this survey.

In the previous reports for the rolling programme, results were compared with earlier NDNS surveys.[1,2,5] Comparisons have not been made in this report but will be included in the report on Years 1 to 4 of the rolling programme due for publication in 2013.

5.2 Foods consumed

Tables 5.1a-c show mean consumption of the standard NDNS food types (for example cereals and cereal products) and food groups (for example white bread) by age and sex, including non-consumers (those who did not consume from a food group during the four-day diary). The tables report foods and dishes as consumed. Mean

consumption figures for the total population (including non-consumers) showed similar results to those seen for Years 1 and 2 combined. Consumption figures for consumers only and the % consumers over four days were presented in previous reports for the rolling programme but are not included in this report.

(**Tables 5.1a-5.1c**)

5.3 Vegetable, fruit, meat and fish consumption, including from composite dishes

This section reports consumption of vegetables, fruit, meat and fish, including the contribution from composite dishes, but excluding the other components of those dishes. All composite dishes in the NDNS Nutrient Databank have been disaggregated into their constituent ingredients so that these can be reported separately. The methodology for the disaggregation of composite dishes is provided in Appendix A.

Fruit and vegetable consumption reported in Table 5.3 is based on disaggregated data. Figures include the fruit and vegetables found in composite dishes. They therefore give higher estimates of consumption than Tables 5.1a - 5.1c as the latter are based on fruit, salad and cooked vegetables consumed and reported as discrete items, and exclude fruit and vegetables in mixed dishes which are reported according to the main component of the dish. Total vegetable consumption based on disaggregated data was 115g per day for children aged 11 to 18 years, 185g per day for adults aged 19 to 64 years and 182g per day for adults aged 65 years and over. Total fruit consumption was 62g per day for children aged 11 to 18 years, 100g per day for adults aged 19 to 64 years and 126g per day for adults aged 65 years and over.

The number of portions of fruit and vegetables consumed per day has also been calculated from the disaggregated data, in line with the "5-a-day" criteria,[6] including up to one portion each of fruit juice and baked beans or pulses per day. For children aged 11 to 18 years,[7] mean consumption was 3.0 "5-a-day" portions per day for boys and 2.8 portions per day for girls. Adults aged 19 to 64 years consumed 4.1 portions per day, while adults aged 65 years and over consumed 4.4 portions per day. The proportion of participants meeting the "5-a-day" guideline was 9% of children aged 11

to 18 years, 31% of adults aged 19 to 64 years and 37% of adults aged 65 years and over.

Meat and fish consumption reported in Table 5.3 is based on disaggregated data. The figures give lower estimates of consumption than Tables 5.1a - 5.1c as the latter include the non-meat and non-fish components of mixed dishes. Total meat consumption based on disaggregated data was 110g per day for adults aged 19 to 64 years and 89g per day for adults aged 65 years and over. Consumption of red meat was 72g per day for adults aged 19 to 64 years and 65g per day for adults aged 65 years and over. Mean consumption of oily fish was well below the recommendation of at least one portion (140g) per week[8] in all age groups: mean consumption was 8g per day in adults aged 19 to 64 years, equivalent to 54g per week and 12g per day in adults aged 65 years and over, equivalent to 85g per week.

(**Table 5.3, Appendix A**)

5.4 Energy and macronutrient intake

This section presents daily intakes of energy and macronutrients estimated from the food consumption data. The percentage contribution of the major food types to energy and macronutrient intake was presented in previous reports for the rolling programme but is not included in this report.

Mean daily intakes of macronutrients are compared with the UK DRVs.[3] For total fat, saturated and *trans* fatty acids and non-milk extrinsic sugars (NMES) the DRVs are the recommended maximum contribution these nutrients should make to the population average diet (Table 5B) and apply to the entire population over the age of five years.

Table 5B: Dietary Reference Values (DRVs) for selected macronutrients

Macronutrient	Dietary Reference Value (DRV)
Total fat	Population average no more than 35% food energy
Saturated fatty acids	Population average no more than 11% food energy
Trans fatty acids	Population average no more than 2% food energy
Non-milk extrinsic sugars (NMES)	Population average no more than 11% food energy

For total carbohydrate, *cis*-monounsaturated fatty acids and non-starch polysaccharide (NSP) the DRVs are recommended population averages. For protein, the Reference Nutrient Intakes (RNIs) are set at levels of intake considered likely to be sufficient to meet the requirements of 97.5% of the population.

- Mean daily intakes for total energy were 4.79 MJ (1137 kcal) for children aged 1.5 to 3 years, 6.55 MJ (1555 kcal) for children aged 4 to 10 years, 7.54 MJ (1791 kcal) for children aged 11 to 18 years, 9.04 MJ (2151 kcal) for men aged 19 to 64 years, 6.79 MJ (1614 kcal) for women aged 19 to 64 years, 8.13 MJ (1934 kcal) for men aged 65 years and over and 6.32 MJ (1501 kcal) for women aged 65 years and over.[9]

- Mean daily protein intakes were well above the RNI in all age and sex groups and provided 14-15% of food energy for children and 17-18% for adults.

- Mean daily intakes of total fat met the DRV of contributing no more than 35% of food energy in all age and sex groups, except for men and women aged 65 years and over, where total fat provided 36.9% and 35.4% food energy respectively.[10]

- Mean intakes of saturated fatty acids exceeded the DRV of providing no more than 11% of food energy in all age groups. Mean intakes provided 13.3% food energy for children aged 4 to 10 years, 12.6% for children aged 11 to 18 years,

12.7% for adults aged 19 to 64 years and 14.2% for adults aged 65 years and over.[10]

- The DRV for *cis*-monounsaturated fatty acids is 13% of food energy as a population average. Mean intakes of *cis*-monounsaturated fatty acids provided 11-13% of food energy for children and 12-13% for adults.[10]

- Mean *trans* fatty acid intakes met the DRV of providing no more than 2% of food energy in all age groups, representing 0.7-0.8% of food energy. Intakes at the upper 2.5 percentile also met the DRV in all age groups.

- The DRV for total carbohydrate is 50% of food energy as a population average. Mean total carbohydrate intakes ranged from 46.5% food energy for adults aged 65 years and over to 51.9% for children aged 4 to 10 years.

- Mean intakes of NMES exceeded the DRV of providing no more than 11% of food energy in all age and sex groups, ranging from 11.4% for adults aged 65 years and over and 11.8% for children aged 1.5 to 3 years to 15.3% for children aged 11 to 18 years.

- Mean intakes of NSP were 8.2g per day for children aged 1.5 to 3 years and 11.3-11.8g per day for children aged 4 to 18 years. For adults aged 19 years and over, the DRV is set at a population average intake of 18g per day; mean intakes were well below this at 13.3-13.8g per day.

(**Table 5.4**)

Vitamins and minerals

Intakes of vitamins and minerals are reported in two ways: from foods only and from all sources, that is, including dietary supplements, as recorded in the four-day diary. The percentage of individuals taking dietary supplements is reported in Section 5.7.

For those vitamins and minerals where UK Reference Nutrient Intakes (RNIs) and Lower Reference Nutrient Intakes (LRNIs) have been published,[3] the proportions of

participants with intakes below the LRNI is shown and mean daily intakes are compared with the RNI. 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 possible that some of the group will have an intake below their requirement. 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. It should 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.

5.5.1 Vitamins

Average daily intakes of vitamins from food sources, expressed as a percentage of RNI, were close to or above 100% of the RNI for all age and sex groups, with the exception of vitamin D. For vitamin D, RNIs are only set for those aged up to 4 years and those aged 65 years and over. Mean intakes from food sources were well below the RNI in both these age groups: 26% of the RNI for children aged 1.5 to 3 years and 33% for adults aged 65 years and over. Inclusion of intakes from dietary supplements containing vitamin D brought the mean intake up to 32% of the RNI for children aged 1.5 to 3 years and 47% for adults aged 65 years and over, but mean intakes remained well below the RNI.

For vitamin A, 13% of children aged 11 to 18 years had intakes from food sources only below the LRNI. Twenty-one percent of girls aged 11 to 18 years and 12% of women aged 19 to 64 years had riboflavin intakes below the LRNI. Inclusion of dietary supplements providing vitamins had little effect on the percentages with intakes below the LRNI.

(**Tables 5.14, 5.16-5.17a**)

5.5.2 Minerals

Average daily intakes of minerals from food sources, expressed as a percentage of RNI, were below 100% of RNI for some age and sex groups. Children aged 11 to 18 years, especially girls, were more likely to have mean intakes below the RNI compared with the other age groups. Inclusion of intakes from dietary supplements containing minerals made little difference to mean intakes in terms of groups meeting the RNI. The exception was iron-containing supplements for women aged 19 to 64 years; these brought the mean intake up from 79% to 98% of the RNI, although there was little change to the median intake suggesting that those with higher intakes from food sources were taking these supplements.

A high percentage of girls aged 11 to 18 years had intakes below the LRNI for many of the minerals assessed. Fifty-one per cent of girls in this age group had magnesium intakes from food sources below the LRNI and 46% had iron intakes below the LRNI. Iron intakes were below the LRNI for 23% of women aged 19 to 64 years. Selenium intakes were below the LRNI for 33% of children aged 11 to 18 years, 39% of adults aged 19 to 64 years and 44% of adults and 65 years and over. Dietary supplements providing minerals had little impact on the proportions with intakes below the LRNI.

(**Tables 5.18-5.21a**)

5.6 Alcohol

This section reports on alcohol intake in grams per day and as a per cent of total energy only, for both the total population (including non-consumers) and consumers only (those who reported consumption of alcoholic beverages in the four-day diary and includes those who consumed alcohol in recipes and other foods). In the Years 1, 2 and 3 combined data, weekend days are disproportionately represented and this should be taken into account when interpreting findings on alcohol intake.

For adult consumers, alcohol provided on average 8.7% and 6.9% of energy intake for those aged 19 to 64 years and 65 years and over respectively. For male consumers, intakes at the upper 2.5 percentile provided 35.0% of energy intake from alcohol over the four-day period for those aged 19 to 64 years and 23.7% for those aged 65 years and over.

Fifteen per cent of participants aged 11 to 18 years consumed alcohol in some form during the four-day recording period, and for them, alcohol provided on average 6.2% of energy intake for boys and 5.8% of energy intake for girls. At the upper 2.5 percentile, alcohol provided 26.7% of energy intake for male consumers and 31.9% of energy intake for female consumers. It should be noted that most of the consumers of alcoholic beverages in the 11 to 18 years age group were aged 15 to 18 years.

Questions about alcoholic beverage consumption are also asked in the CAPI interview and via self-completion for children and young adults. This is reported in Section 3.2 in terms of units of alcohol and related to recommended sensible drinking guidelines. The time period recalled in the CAPI/self-completions is the seven days before interview and so does not overlap with the diary recording period.

(**Table 5.22**)

5.7 Dietary supplements

Information on consumption of dietary supplements was collected both in the four-day food diary and in the CAPI interview, which asks about consumption in the year before interview. Dietary supplements were defined for participants as products intended to provide additional nutrients or give health benefits and taken in liquid, powder, tablet or capsule form. In the CAPI, participants were asked to list any dietary supplements taken over the past year. In the diary, participants wrote down the details of the supplements they took on each diary recording day.

Twenty-three per cent of adults aged 19 to 64 years (17% of men, 29% of women) and 39% of adults aged 65 years and over (36% of men, 41% of women) had taken at least one supplement during the four-day diary recording period.

Except for women aged 65 years and over, a higher proportion of participants reported in the CAPI having taken at least one supplement during the previous year than had done so in the four-day diary period: 33% of adults aged 19 to 64 years and 40% of adults aged 65 years and over reported having taken supplements in the past year.

This may be because of infrequent, intermittent or seasonal use of supplements which may not have been captured in the diary period.

For most age groups, the two most common types of supplements were fish oils (including cod liver oil) and multivitamins with or without minerals.

(**Tables 5.29 and 5.30**)

[1] [Online]. Available: http://tna.europarchive.org/20110116113217/tna.europarchive.org/20110116113217/http://www.food.gov.uk/science/dietarysurveys/ndnsdocuments/ndns0809year1 (accessed 02/02/12)

[2] [Online]. Available: http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsStatistics/DH_128166 (accessed 02/02/12).

[3] Report on Health and Social Subjects 41 *Dietary Reference Values (DRVs) for Food Energy and Nutrients for the UK*, Report of the Panel on DRVs of the Committee on Medical Aspects of Food Policy (COMA) 1991. The Stationery Office. London

[4] The doubly labelled water technique (DLW) is widely agreed to be the most accurate way of assessing energy expenditure over several weeks. Participants in DLW studies drink a weighed amount of water labelled with known amounts of the stable isotopes of hydrogen (^2H) 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. Energy expenditure can then be estimated from the CO_2 production.

[5] Any comparisons between intakes in this and previous surveys should be made using recalculated intakes and not the seven-day data from the published reports. Recalculated values and details on the methodology can be found in Appendix K of the reports for Year 1 and Years 1 and 2 combined.

[6] [Online]. Available: http://www.nhs.uk/Livewell/5ADAY/Pages/5ADAYhome.aspx (accessed 02/02/12).

[7] Results have not been reported for children aged under 11 years since the standard 80g portion used in the analysis may be too large for younger children and a smaller portion size has yet to be set for this age group.

[8] Scientific Advisory Committee on Nutrition. Advice on fish consumption: benefits and risks. London: TSO, 2004

[9] Average energy intakes in NDNS, as in all dietary surveys, are known to be under-reported, especially in many adults and older children. Results from an assessment of under-reporting of energy intake in a sub-sample using the doubly labelled water technique will be included in a future report.

[10] This recommendation applies to adults and children from the age of five years.

6 Blood analytes

Sonja Nicholson, Gerda Pot, Chris Bates and Ann Prentice

6.1 Introduction

This chapter reports the results of the analysis of blood samples taken from participants aged 11 to 18 years and 19 to 64 years during the nurse stage (stage two) of Years 1, 2 and 3 of the NDNS rolling programme. Blood samples were also collected from participants aged 1.5 to 10 years and 65 years and over and these will be reported in the future when sample numbers have accumulated. Samples were collected between February 2008 and July 2011. In Year 1 there was a two week time lag between the start of the interviewer and nurse stages. From Year 2 onwards, the gap was extended, to an average of eight weeks, with the aim of increasing nurse stage response rates.

The results in Chapter 5 are based on assessment of food consumption over four days and indicate dietary intake over a short period. Analysis of blood samples provides an indication of the nutritional status of the population usually over a longer period. Nutritional status means the level of nutrients available to the body (after absorption) for use in metabolic processes. For some micronutrients, status can be assessed by directly measuring the level of the nutrient in blood, while for others it is assessed by a functional measure such as the cofactor saturation of vitamin-dependent enzymes.

An overview of the purpose, methodologies and other procedures associated with obtaining blood samples from participants, as well as the response rates achieved, are provided in Chapters 1 to 3. Appendix H contains examples of consent forms used in the rolling programme. Examples of the letters sent to a participant and/or their GP containing results for reportable analytes measured in their blood sample are presented in Appendix J. The priority order of analytes for participants aged 1.5 to 6 years, 7 to 15 years and 16 years and over are listed in Appendix L. Analytes were given a priority order for analysis according to their clinical and public health importance. Appendix M details the procedures for obtaining written consent from adult participants and the parent/legal guardian of child participants, including child

assent where appropriate, prior to blood sampling. Appendix M also provides information about obtaining and processing blood samples, the recruitment of field laboratories and the transport and storage of blood samples. Appendix N details the quality control data and methodology of blood analysis for each analyte described in this report. The nurse (stage two) participant information documents are provided in Appendix O. Appendix Q details which analytes are reported for Years 1, 2 and 3 combined as well as providing details about analytes that are not reported but will be included in the dataset deposited at the UK Data Archive[1] and those that will be reported and included in the archived dataset in the future.

6.1.1 Obtaining the blood sample

All fully productive participants[2] aged 1.5 years and over who were visited by a nurse (2,318 individuals) were asked whether they would consent to give a blood sample. In the case of children aged under 16 years, consent was also sought from a parent or legal guardian. Participants who consented to providing a blood sample were visited by a nurse (in the case of children aged 1.5 to 10 years by a paediatric phlebotomist) to attempt venepuncture. Ethical approval was gained to obtain a maximum of 10.9mL of blood from participants aged 1.5 to 6 years, 21.1mL from participants aged 7 to 15 years and 35.1mL for participants aged 16 years and over. Blood samples were collected by a qualified nurse or paediatric phlebotomist using a Sarstedt fixed or butterfly needle, depending on the blood taker's preference. The monovette tube system was used as it is a closed system, and allows the safe collection of blood in a participant's home. Children aged 1.5 to 15 years who had consented to provide a blood sample were offered the option of anaesthetic gel being applied prior to venepuncture.

Blood was collected in up to a maximum of eight tubes, depending on the age group of the participant. Each tube contained a different anticoagulant/stabilising agent as appropriate for the analysis required.

For participants aged 1.5 to 6 years, 7 to 15 years and 16 years and over, the following monovette tubes were filled:

Age group	Tubes
1.5 to 6 years	1 x EDTA, 1 x lithium heparin, 1 x serum gel and 1 x serum
7 to 15 years	1 x EDTA, 1 x trace mineral controlled lithium heparin, and 1 x lithium heparin, 1 x serum gel, 1 x serum and 1 x fluoride
16 years and over	2 x EDTA, 2 x trace mineral controlled lithium heparin, and 1 x lithium heparin, 1 x serum gel, 1 x serum and 1 x fluoride

Of those completing at least three diary days, 50% of adults and 27% of children provided a blood sample. Younger children were less likely to give a blood sample than older children or adults: 19% of those aged 1.5 to 10 years did so compared with 38% of those aged 11 to 18 years and 50% of those aged 19 years and over. The numbers in each age group vary slightly for each analyte because, when the quantity of blood collected was not sufficient, lower priority analytes may not have been assayed for some individuals. The primary reasons for a sample not being obtained, when prior consent had been given, was not being able to find a suitable vein or a vein collapsing during the procedure. Further details are provided in Chapter 2 and Appendix M.

Blood samples were obtained from a total of 1,169 fully productive participants. This report presents results for all or some analytes for 241 children aged 11 to 18 years and 549 adults aged 19 to 64 years.

6.1.2 Fasted blood samples

Participants aged four years and over were asked to provide an overnight fasting blood sample. Children aged 1.5 to 3 years and diabetics (not willing to fast) were invited to provide a non-fasting blood sample. All other participants, including diabetics who were willing to fast, were invited to provide an overnight (eight hour) fasting blood sample. Requirements for blood processing to commence within two hours of collection, and for procedure-standardisation, dictated that all samples had to be collected as early in the day as possible, and in all cases before midday.

6.1.3 Transport and storage of blood samples

Following venepuncture, an EDTA and a serum gel monovette tube from each participant's sample set were sent by post, to the Immunology and Biochemistry Laboratory at Addenbrooke's Hospital in Cambridge (Addenbrooke's) for prompt analysis. The remaining blood monovette tubes from a participant's sample set were taken to a local field laboratory, to be processed and stored below -40^{o}C (or at a maximum of -20^{o}C where -40^{o}C facilities were not available) before they were transported on dry ice to HNR for analysis. Appendix M provides further details on the transport, tracking and storage of blood samples.

6.1.4 Analysis of the blood samples

Blood analytes were assigned a priority order based on clinical and policy relevance. Where it was not possible to obtain the full volume of blood from a participant, analytes were assayed in the order of priority detailed in Tables L.1, L.2 and L.3 (Appendix L). Therefore the base numbers in the tables may be smaller for the lower priority analytes in each monovette tube than for the higher priority ones.

The analytes presented in this report have been divided into the following main groups:

- haematology, including measures of iron status
- water-soluble vitamins and total homocysteine
- fat-soluble vitamins and carotenoids
- blood lipids
- zinc and selenium

In addition to the blood analytes presented in Tables 6.1 to 6.5, other analytes listed in Appendix L were measured. These analytes, further details for which are provided in Appendix Q were included in the dataset submitted to the UK Data Archive.[1]

Appendix N provides details on the quality control measures for all of the assays performed on blood samples in the NDNS rolling programme. All of the laboratories analysing blood samples were participating in external quality assessment schemes.

Data for the blood analytes in Tables 6.1 to 6.5 have been weighted to account for differential non-response to providing a blood sample, in order to adjust for any bias arising from blood sampling refusals and/or failures. Details of the methodology used to weight the data are provided in Chapter 2 and Appendix B. Notional values were assigned to results below the limit of detection. These were calculated by dividing the analytical limit of detection by the square root of two. This method is consistent with that used in NHANES and has been described by Hornung and Reed (1990).[3] Results are presented for the age groups 11 to 18 years and 19 to 64 years and are split by sex. Results for children aged 1.5 to 10 years and adults aged 65 years and over have not been reported due to small sample sizes, but will be reported in the future by combining several years of data.

No comparisons are made with blood analytes data from previous NDNS surveys due to the small numbers accumulated so far in the current survey and because some of the methods used in the rolling programme are different to those used in previous NDNS.[4,5,6,7] Due to small numbers for each sex/age group included in this report, the upper or lower 2.5th percentiles have not been provided in the tables or the text. However, where there are threshold concentrations for an analyte the percentage of participants above or below an accepted threshold, where a low status is indicated, have been provided in Tables 6.1 to 6.5.

6.2 Haematology, ferritin and C-reactive protein

6.2.1 Haemoglobin concentration (*grams/litre, g/L*)

Haemoglobin is the iron-containing, oxygen-carrying, molecule in red blood cells. Circulating levels of haemoglobin are indicative of the oxygen-carrying capacity of the blood and a low haemoglobin concentration can indicate iron deficiency (anaemia). The lower limits for haemoglobin below which anaemia is indicated are 115g/L and 120g/L for children aged 5 to 11 years and 12 to 14 years respectively and 130g/L and 120g/L for men and non-pregnant women aged 15 years and over respectively. The haemoglobin concentrations for women of childbearing age tend to be lower than in other population groups because of menstrual loss. These lower limits for haemoglobin have been set by the World Health Organization (WHO)[8] and are endorsed by the Scientific Advisory Committee for Nutrition (SACN).[9]

The mean haemoglobin concentrations for boys and girls aged 11 to 18 years were above the lower limits at 144.0g/L and 131.0g/L respectively.[8,9] The mean haemoglobin concentrations for men and women aged 19 to 64 years were also above the lower limits at 149.7g/L and 133.0g/L respectively.[8] The proportions with haemoglobin concentrations below the lower limits[8, 9] were 1.1% for boys aged 11 to 18 years, 8.8% for girls aged 11 to 18 years 1.3% for men aged 19 to 64 years and 9.8% for women aged 19 to 64 years.

(**Table 6.1**)

6.2.2 Plasma ferritin (*micrograms/litre, μg/L*)

Ferritin is an intracellular protein that stores iron. Plasma ferritin gives an indication of the level of iron stores. However, plasma ferritin is an acute phase reactant that is raised in response to infection or inflammation. Therefore plasma ferritin concentrations should be interpreted with care as they can be raised by recent infections or inflammatory conditions, cardiovascular disease, liver disease and other chronic disorders.[9]

The lower limit for plasma ferritin below which iron stores are considered to be depleted and the risk of iron-deficiency anaemia increased is 15μg/L for children aged 11 years to 14 years and for men and non-pregnant women aged 15 years and over.[8,9]

The mean plasma ferritin values for boys and girls aged 11 to 18 years were 43μg/L and 28μg/L respectively and for men and women aged 19 to 64 years 138μg/L and 56μg/L respectively. The mean ferritin values for all age/sex groups were above the lower limit of the normal range for the equivalent age/sex groups.[8,9] The proportion of boys aged 11 to 18 years and girls aged 11 to 18 years with ferritin concentrations below the lower limit of the normal range was 7.6% and 30.2% respectively. The proportion of men aged 19 to 64 years and women aged 19 to 64 years with ferritin concentrations below the lower limit of the normal range was 3.2% and 16.6% respectively.

(**Table 6.1**)

6.2.3 Combined index: Haemoglobin concentration (*grams/litre, g/L*) and Plasma ferritin (*micrograms/litre, μg/L*)

Assessment of an individual's iron status depends on the measurement, interpretation and synthesis of various markers of iron status. Determining adequate iron status is dependent on the measure of more than one marker.[9] The combination of haemoglobin and ferritin concentrations can be used as a measure of iron status and/or deficiency.

The proportion of boys and girls aged 11 to 18 years with haemoglobin concentrations and plasma ferritin concentrations below which anaemia is indicated was 0.0% and 5.6% respectively. The proportion of men and women aged 19 to 64 years with haemoglobin concentrations and plasma ferritin concentrations below which anaemia is indicated was 0.7% and 3.3% respectively.

(**Table 6.1**)

6.2.4 Haematocrit (packed cell volume – PCV) (*litres/litre fractional volume, L/L*)

Haematocrit is the proportion of the blood volume taken up by the red cells and is determined by the cell size and number. A lower concentration may indicate abnormal cell development, as shown by abnormally small red blood cells (microcytosis) as occurs in iron-deficiency anaemia. Haematocrit values for men aged 16 years and over are usually between 0.40L/L and 0.50L/L, whilst those for women aged 16 years and over are usually between 0.36L/L and 0.46L/L.[10] WHO lower limits for haematocrit levels below which anaemia is present in a population are 0.34L/L for children aged 11 years, 0.36L/L for children aged 12 to 14 years and non-pregnant women aged 15 years and over, and 0.39L/L for men aged 15 years and over. [8]

The mean haematocrit values for all sex/age groups were above the lower limits.[8] The proportion of boys and girls aged 11 to 18 years and men and women aged 19 to 64 years with haematocrit concentrations below which anaemia is indicated was 0.0%, 7.3%, 2.5% and 11.6% respectively.

(**Table 6.1**)

6.2.5 Serum high sensitivity C-reactive protein (*milligrams/litre, mg/L*)

High sensitivity C-reactive protein (Hs-CRP) is an acute phase protein, the serum levels of which rise during a general, non-specific response to infections and non-infectious inflammatory processes such as rheumatoid arthritis, cardiovascular disease and peripheral vascular disease.[9] The rolling programme is the first time Hs-CRP has been measured in NDNS, since alpha$_1$-antichymotrypsin was used in previous NDNS as the acute phase marker.

Results for Hs-CRP concentrations in serum are shown in Table 6.1.

(**Table 6.1**)

6.3 Water-soluble vitamins and plasma total homocysteine

6.3.1 Plasma vitamin C (*micromoles/litre, μmol/L*)

Vitamin C is needed for the maintenance of healthy connective tissue in the body and clinical deficiency results in scurvy. Vitamin C acts as an antioxidant, protecting cells from the damage caused by oxidative free radicals. Plasma vitamin C concentrations reflect recent dietary intakes of vitamin C, with values of less than 11μmol/l indicative of biochemical depletion.[11]

The mean plasma vitamin C concentration for boys aged 11 to 18 years was 56.7μmol/L and for girls aged 11 to 18 years 55.8μmol/L and both were above the level indicative of biochemical depletion. The mean plasma vitamin C concentration for men aged 19 to 64 years was 49.9μmol/L and for women aged 19 to 64 years 55.2μmol/L and both were above the level indicative of biochemical depletion. The proportion of boys and girls aged 11 to 18 years with a vitamin C concentration below the level indicative of biochemical depletion was 0.3% and 0.0% respectively, whilst 0.9% of men and 2.4% of women aged 19 to 64 years had a vitamin C concentration below the level indicative of biochemical depletion.

(**Table 6.2**)

6.3.2 Serum vitamin B_{12} (*picomoles/litre, pmol/L*)

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. Serum concentration of vitamin B_{12} is the commonly used measure of vitamin B_{12} status. Vitamin B_{12}, with folate, is required for methyl group transfer during protein metabolism, DNA synthesis and the methylation of DNA and various other substrates. The commonest cause of vitamin B_{12} deficiency is failure of the parietal cell of the stomach to secrete an intrinsic factor (a protein cofactor), leading to impaired absorption and hence pernicious anaemia.[12] The lower level of the normal range for serum vitamin B_{12} concentration for all ages is usually taken as 150pmol/L.[13]

The mean serum vitamin B_{12} concentration for boys aged 11 to 18 years was 314pmol/L and for girls aged 11 to 18 years 308pmol/L. The mean serum vitamin B_{12} concentration for men aged 19 to 64 years was 308pmol/L and for women aged 19 to 64 years 298pmol/L. The proportion of boys and girls aged 11 to 18 years with a vitamin B_{12} concentration below the lower threshold of the normal range of 150pmol/L was 1.9% and 4.2% respectively, whilst 0.9% of men and 3.3% of women aged 19 to 64 years had a vitamin B_{12} concentration below the lower threshold of the normal range.

(**Table 6.2**)

6.3.3 Erythrocyte Transketolase Activation Coefficient (ETKAC) for thiamin status (*ratio*)

Thiamin (vitamin B_1) status is measured by ETKAC. Thiamin is required mainly during the metabolism of carbohydrate, fat and alcohol. Diets high in carbohydrate require higher intake of thiamin than diets high in fat.[12] As with most water-soluble vitamins, there is no recognisable store of non-functional thiamin in the body and the only reserve is that which is functionally bound to enzymes within the tissues by the cofactor, thiamin diphosphate. ETKAC depends on the reactivation of the cofactor-depleted red cell enzyme transketolase *in vitro*. This index is sensitive to the lower to moderate range of intakes of thiamin. For adults aged 19 to 64 years, values above 1.25 are indicative of biochemical thiamin deficiency.[14]

The mean ETKAC in boys aged 11 to 18 years and also in girls aged 11 to 18 years was 1.12; the mean ETKAC was 1.12 and 1.11 in men aged 19 to 64 years and in women aged 19 to 64 years respectively. The proportion of males and females aged 11 to 64 years with an ETKAC value above 1.25, indicative of biochemical thiamin deficiency, ranged from 0.0%-1.4%.

(**Table 6.2**)

6.3.4 Erythrocyte Glutathione Reductase Activation Coefficient (EGRAC) for riboflavin status (*ratio*)

EGRAC is a measure of red cell enzyme saturation with its cofactor flavin adenine dinucleotide (FAD) derived from riboflavin (vitamin B_2). Riboflavin is needed for the utilisation of energy from food and is a cofactor in the metabolism of other B vitamins. It may also be important for the metabolism of iron. The coefficient is expressed as the ratio of two activity measures of the enzyme glutathione reductase, with and without added FAD in vitro. The higher the EGRAC, the lower the saturation *in vitro*. A coefficient between 1.0 and 1.3 is generally considered to be normal.[15] The test is most sensitive at low levels of riboflavin intake. The EGRAC index is highly sensitive to small degrees of cofactor desaturation and raised values are indicative of low vitamin B_2 status. Although moderately raised values are not consistently associated with known functional abnormality, high values indicative of riboflavin deficiency may be associated with compromised iron metabolism.[16]

The mean EGRAC in boys and girls aged 11 to 18 years was 1.46 and 1.52 respectively, whilst the mean EGRAC in men and women aged 19 to 64 years was 1.38 and 1.42 respectively. All sex/age groups had mean EGRAC greater than 1.30, the generally accepted upper threshold for normal riboflavin (vitamin B_2) status. The proportions with an EGRAC above the 1.30 threshold were 73.7% (boys aged 11 to 18 years), 89.2% (girls aged 11 to 18 years), 65.3% (men aged 19 to 64 years) and 65.5% (women aged 19 to 64 years). However recent research has indicated that the 1.30 threshold may be set too low so giving an overestimate of the prevalence of low riboflavin status. It has been recommended that the EGRAC threshold should be raised to a level above 1.30 to better recognise functionally-significant riboflavin inadequacy; this requires further consideration.[16]

(**Table 6.2**)

6.3.5 Plasma pyridoxal-5-phosphate (*nanomoles/litre, nmol/L*)

Pyridoxal-5-phosphate (PLP) is the primary biologically active form of vitamin B_6, serving as a co-enzyme for a large number of enzymes which catalyse reactions of amino acids.[12] It should be noted that PLP was not measured in previous NDNS.[4, 5, 6,7] Previous NDNS surveys measured erythrocyte aspartate aminotransferase activation coefficient (EAATAC) as an index of vitamin B_6 status. There is currently no internationally recognised normal range for PLP concentration.

The mean plasma PLP concentration in boys aged 11 to 18 years was 71.8nmol/L and in girls aged 11 to 18 years 61.7nmol/L, whilst the mean PLP concentration for men aged 19 to 64 years was 73.1nmol/L and for women aged 19 to 64 years 55.5nmol/L.

(**Table 6.2**)

6.3.6 Plasma total homocysteine (*micromoles/litre, μmol/L*)

Homocysteine is an amino-acid which can be recycled into methionine, a process requiring both folate and vitamin $B_{12.}$ Plasma total homocysteine (tHcy) is therefore sensitive to changes in folate and vitamin B_{12} status, and, because of a role in folate metabolism, riboflavin status can also influence plasma tHcy. Additionally, because of another, vitamin B_6-dependent, turnover pathway, plasma tHcy can become sensitive to changes in vitamin B_6 status. For these reasons, plasma tHcy is sometimes used as a biomarker of adequacy of some B vitamins. Previous studies have suggested an association between relatively high plasma tHcy concentrations and increased risk of vascular diseases, although the findings have been inconsistent. Plasma tHcy concentrations less than or equal to 12μmol/L are considered normal for adults but concentrations below 10μmol/L are considered optimal.[17,18]

As shown in Table 6.2, mean concentrations of homocysteine for males and females aged 11 to 64 years were below 12μmol/L. Boys and girls aged 11 to 18 years had mean plasma homocysteine concentrations of 8.4μmol/L and 8.3μmol/L respectively. Men and women aged 19 to 64 years had mean plasma homocysteine concentrations of 10.1μmol/L and 8.8μmol/L respectively. The proportion of men and

women aged 19 to 64 years who had homocysteine concentrations above 12μmol/L was 13.8% and 8.6% respectively.

(**Table 6.2**)

6.3.7 Folate

Folate results are not presented in this report, but will be published in future reports. Frozen serum samples have been stored and are being analysed by liquid chromatography tandem mass spectrometry (LC MS/MS) and frozen whole blood samples are being analysed by a microbiological method.

6.4 Fat-soluble vitamins and carotenoids

6.4.1 Plasma retinol (vitamin A) (*micromoles/litre, μmol/L*)

Plasma retinol is related to long-term dietary intake of preformed vitamin A. The plasma concentration is homeostatically controlled with little variation either within or between individuals.[19] For adults, concentrations below 0.35μmol/L are considered to reflect severe deficiency and concentrations between 0.35μmol/L and 0.70μmol/L to reflect mild deficiency.[14]

The mean plasma retinol concentration for boys aged 11 to 18 years was 1.63μmol/L and for girls aged 11 to 18 years 1.65μmol/L. The mean plasma retinol concentration for men aged 19 to 64 years 2.32μmol/L and for women aged 19 to 64 years 2.06μmol/L. Thus, the mean levels for all sex/age groups were above the limit of marginal status for retinol. The proportion of men and women aged 19 to 64 years who had a retinol concentration below the level associated with severe deficiency (0.35μmol/L) was 0% and 0.5% respectively. The proportion of men and women aged 19 to 64 years who had a retinol concentration at a level associated with mild deficiency (0.35-0.70μmol/L) was 0% and 0.5% respectively.

(**Table 6.3**)

6.4.2 Plasma α- and β-carotene and α- and β-cryptoxanthin (*micromoles/litre, μmol/L*)

Plasma α- and β-carotene and α– and β–cryptoxanthin are carotenoids with vitamin A activity and reflect short to medium term intakes over a wide range. Concentration of these carotenoids may also be influenced by conversion to vitamin A, the conversion being dependent on vitamin A status and requirements. There are currently no established normal ranges for plasma α- and β-carotene or α- and β–cryptoxanthin.

Results for plasma concentrations of α- and β-carotene and α– and β–cryptoxanthin are shown in Table 6.3.

(**Table 6.3**)

6.4.3 Plasma lycopene and plasma lutein and zeaxanthin (*micromoles/litre, μmol/L*)

Lycopene, lutein and zeaxanthin are also carotenoids but do not have provitamin A activity. Plasma lutein and zeaxanthin may be useful markers of green vegetable intake. There are currently no established normal ranges for plasma concentrations of these carotenoids.

Results for plasma concentrations of lycopene, lutein and zeaxanthin are shown in Table 6.3.

(**Table 6.3**)

6.4.4 Plasma 25-hydroxyvitamin D (*nanomoles/litre, nmol/L*)

Plasma 25-hydroxyvitamin D (25-OHD) is a measure of vitamin D status and reflects the availability of vitamin D in the body from both dietary and endogenous sources. Plasma 25-OHD is derived from synthesis in the skin of cholecalciferol during ultraviolet B irradiation from sunlight and from ergocalciferol and cholecalciferol in the diet. Factors such as the season, habit of dress and time spent outdoors during the year therefore influence 25-OHD as well as intake from foods and supplements. Vitamin D after conversion to its active metabolites facilitates calcium absorption from the intestine and is important for a range of other metabolic processes. In the UK

25nmol/L of 25-OHD has been used as the lower threshold for vitamin D adequacy below which there is an increased risk of rickets and osteomalacia.[20,21] It has been suggested that a higher value should be used to indicate the lower threshold of population vitamin D sufficiency but there is currently no consensus on which value should be selected. SACN convened a working group in 2011 to review the thresholds. Plasma 25-OHD is not split by season in this report due to small sample sizes. Further, because the survey was spread evenly across the year, values in Table 6.3 are year-round averages.

Mean 25-OHD concentrations were 46.1nmol/L for boys aged 11 to 18 years and 42.5nmol/L for girls aged 11 to 18 years, whilst mean 25-OHD concentrations were 45.6nmol/L for men aged 19 to 64 years and 49.6nmol/L for women aged 19-64 years. The proportion of boys and girls aged 11 to 18 years and men and women aged 19 to 64 years who had 25-OHD concentrations below the lower threshold for vitamin D adequacy were 19.3%, 20.4%, 17.1% and 18.6% respectively. The distribution of the data provides evidence of low vitamin D status in adults and older children, both male and female.

(**Table 6.3**)

6.4.5 Plasma α-tocopherol (*micromoles/litre, μmol/L*)

Plasma α–tocopherol concentration can be used as a measure of vitamin E status. Alpha-tocopherol is the predominant form in human tissues and has the highest biological activity of the tocopherols. Increased concentration of plasma lipids appears to cause tocopherols to partition out of cellular membranes, thus increasing plasma concentrations of tocopherols and resulting in a correlation between tocopherols and total lipid in the blood, particularly with the cholesterol fraction. For this reason plasma tocopherols can be usefully expressed as a ratio to plasma total cholesterol (μmol/mmol), enabling comparisons to be made between groups with different plasma lipid levels. For adults, plasma tocopherols below 11.6μmol/L, of which approximately 93% would be α–tocopherol, or a plasma tocopherols to cholesterol ratio of below 2.25μmol/mmol, tend to cause red blood cells to haemolyse after exposure to oxidising agents *in vitro*, which is a functional test for vitamin E deficiency. This is sometimes considered to be an indicator of biochemical deficiency but is not indicative of a clinical deficiency of vitamin E. There is currently no

established normal range for plasma α-tocopherol concentration. The Committee on Medical Aspects of Food and Nutrition Policy (COMA) Panel on Dietary Reference Values considered a tocopherol to cholesterol ratio of 2.25μmol/mmol to be the lowest satisfactory value for adults.[12]

Mean plasma α-tocopherol concentrations were 23.5μmol/L for boys aged 11 to 18 years and 25.9μmol/L for girls aged 11 to 18 years. Mean plasma α-tocopherol concentrations were 32.8μmol/L for men aged 19 to 64 years and 32.8μmol/L for women aged 19 to 64 years. Alpha-tocopherol results expressed as the ratio to total cholesterol in μmol/mmol have also been provided in Table 6.3 for each sex/age group. Mean ratio of α-tocopherol to total cholesterol were 6.48μmol/mmol for men aged 19 to 64 years and 6.26μmol/mmol for women aged 19 to 64 years, with 100% of men and women aged 19 to 64 years having a ratio of α-tocopherol to total cholesterol greater than the lowest satisfactory value.

(**Table 6.3**)

6.5 Blood lipids

6.5.1 Total cholesterol, high density lipoprotein (HDL) cholesterol and low density lipoprotein (LDL) cholesterol (*millimoles/litre, mmol/L*)

High circulating levels of serum total cholesterol and LDL cholesterol are among the predictors of coronary heart disease (CHD) and other vascular diseases in adults. They are affected by age, genetic and environmental influences, including dietary factors, notably the amount of saturated fatty acids in the diet. [22] High levels of total cholesterol occur in some diseases, for example kidney, liver and thyroid disorders or in diabetes.

Cholesterol circulates in the body carried by a variety of proteins, namely the lipoproteins. Cholesterol transported in low density lipoproteins (LDL cholesterol) is the major proportion of total circulating cholesterol. In adults, the risk of CHD is positively correlated with concentrations of both serum total cholesterol and LDL cholesterol. Cholesterol transported in high density lipoproteins (HDL cholesterol) is a smaller proportion of the total circulating cholesterol and is inversely related to the development of CHD. It is generally accepted that a serum total cholesterol

concentration below 5.2mmol/L represents a level associated with minimal CHD risk, 5.2mmol/L to 6.4mmol/L mildly elevated, 6.5mmol/L to 7.8mmol/L moderately elevated and above 7.8mmol/L a severely elevated level.[23]

In this survey LDL cholesterol was not directly measured but was calculated by subtraction of HDL cholesterol from serum total cholesterol and corrected for serum triglycerides using the Friedewald equation.[24] Serum triglycerides are also measured in the current NDNS programme; however they are not presented in this report, but are included in the dataset sent to the UK Data Archive.[1]

Table 6.4 shows the mean serum total, HDL and LDL cholesterol concentrations for boys and girls aged 11 to 18 years and men and women aged 19 to 64 years. Mean serum total, HDL and LDL cholesterol concentrations for boys aged 11 to 18 years were 4.05, 1.41 and 2.32mmol/L, whilst those for girls aged 11 to 18 years were 4.06, 1.43 and 2.32mmol/L respectively. Mean serum total, HDL and LDL cholesterol concentrations for men aged 19 to 64 years were 5.13, 1.34 and 3.13mmol/L, whilst those for women aged 19 to 64 years were 5.24, 1.62 and 3.15mmol/L respectively. Mean serum total cholesterol concentrations for boys and girls aged 11 to 18 years and men aged 19 to 64 years fell within a category that is associated with minimal risk, whilst mean serum total cholesterol concentrations for women aged 19 to 64 years fell within a category that is associated with mildly elevated risk. Thirty one per cent of men and 36.3% of women aged 19 to 64 years had a total cholesterol concentration at a level associated with mildly elevated risk of cardiovascular disease, whilst 11.4% of men and women aged 19 to 64 years had a total cholesterol concentration at a level associated with moderately elevated risk of cardiovascular disease. The proportion of men and women aged 19 to 64 years who had a total cholesterol concentration at a level associated with severely elevated risk of cardiovascular disease was 1.8% and 2.7% respectively.

(**Table 6.4**)

6.6 Selenium and zinc

6.6.1 Plasma selenium (*micromoles/litre, μmol/L*)

Selenium is an essential trace element. It forms part of the structure of certain proteins, and plays a key role in a number of metabolic processes including

antioxidant systems and thyroid hormone metabolism. There are well-confirmed pathological syndromes associated with selenium deficiency as well as selenium toxicity.[25] There is currently no established normal range for plasma selenium concentration.

Mean plasma selenium concentrations were 0.92µmol/l in both boys and girls aged 11 to 18 years; and similar in men and women aged 19 to 64 years; 1.10µmol/L and 1.06µmol/L respectively.

(**Table 6.5**)

6.6.2 Plasma zinc (*micromoles/litre, µmol/L*)

Zinc is an essential trace element. It has a regulatory and catalytic role in numerous enzymes and also has a structural role in a number of enzymes and non-enzymatic proteins. Zinc also plays a role in major metabolic pathways which contribute to protein, carbohydrate, lipids, nucleic acids and energy metabolism.[12] There is currently no established normal range for plasma zinc concentration.

Mean plasma zinc concentrations were similar across all age/sex groups with concentrations of 15.33µmol/L and 14.57µmol/L in boys aged 11 to 18 years and girls aged 11 to 18 years respectively; and 15.0µmol/L and 14.41µmol/L in men aged 19 to 64 years and women aged 19 to 64 years respectively.

(**Table 6.5**)

6.7 Summary of the nutritional status of the population

Analysis of blood samples can provide an indication of the level of nutrients available to the body (after absorption) for use in metabolic processes.

There is evidence of iron-deficiency anaemia (as indicated by low haemoglobin levels) and low iron stores (plasma ferritin) in a proportion of older girls aged 11 to 18 years and women aged 19 to 64 years. There is evidence of low vitamin D status in all reported age/sex groups which has implications for bone health, in particular increased risk of rickets and osteomalacia. A substantial proportion of children aged 11 to 18 years and adults aged 19 to 64 years have functional riboflavin status values above the generally accepted upper threshold for normal status. However, recent

research has indicated that the threshold may be set too low so giving an overestimate of the prevalence of low riboflavin status.

There is little evidence of low status for other micronutrients where normal ranges or thresholds for low status have been set. Mean values for vitamin C, B_{12}, thiamin, retinol and vitamin E fell within the normal range.

A proportion of adults aged 19 to 64 years had elevated concentrations of serum total cholesterol. The association with increasing risk of cardiovascular disease is well known and in line with findings from health surveys.

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[1] http://www.data-archive.ac.uk (accessed 30/05/12).

[2] Participants are classed as "fully productive" if they have completed three or four days of the food and drink diary.

[3] Hornung, RW, Reed, LD. Applied Occupational and Environmental Hygiene, 1990, 5: 46-51.

[4] Rustin D, Hoare J, Henderson L, Gregory J, Bates CJ, Prentice A, Birch M. National Diet and Nutrition Survey: adults aged 19 to 64 years. Volume 4: Nutritional status (anthropometry and blood analytes), blood pressure and physical activity. TSO (London, 2004). http://www.food.gov.uk/multimedia/pdfs/ndnsprintedreport.pdf.

[5] Gregory J, Lowe S, Bates CJ, Prentice A, Jackson LV, Smithers G, Wenlock, R, Farron M. National Diet and Nutrition Survey: young people aged 4 to 18 years. Volume 1: Report of the diet and nutrition survey. TSO (London, 2000).

[6] Finch S, Doyle W, Lowe C, Bates CJ, Prentice A, Smithers G, Clarke PC. National Diet and Nutrition Survey: people aged 65 years and over. Volume 1: Report of the diet and nutrition survey. TSO (London, 1998). http://www.esds.ac.uk/findingData/snDescription.asp?sn=4036

[7] Gregory JR, Collins DL, Davies PSW, Hughes JM, Clarke PC. National Diet and Nutrition Survey: children aged 1 ½ to 4 ½ years. Volume 1: Report of the diet and nutrition survey. HMSO (London, 1995).

[8] World Health Organization. Iron Deficiency Anaemia; Assessment, Prevention, and Control: A guide for programme managers. WHO (Geneva, 2001).

[9] Scientific Advisory Committee on Nutrition. *Iron and Health*. The Stationery Office (London, 2010).

[10] Dacie JV, Lewis SM. Practical Haematology. 9th Edition. Churchill Livingstone (Edinburgh, 2001).

[11] Sauberlich HE. Vitamin C status: methods and findings. Annals of the New York Academy of Sciences, 1971; 24: 444–454.

[12] Committee on Medical Aspects of Food Policy, *Dietary Reference Values for Food Energy and Nutrients for the United Kingdom*, Department of Health Report on Health (1991).

[13] WHO. Conclusions of a WHO technical consultation on folate and vitamin B_{12} deficiencies. Food and Nutrition Bulletin. 2008; 29. S238–S244.

[14] Bates CJ, Thurnham DI, Bingham SA, Margetts BM, Nelson M. Biochemical Markers of Nutrient Intake. In: Design Concepts in Nutritional Epidemiology. 2nd Edition. OUP (Oxford, 1997), pp 170–240.

[15] Hill MH, Bradley A, Mustaq S, Williams EA, Powers HJ. Effects of methodological variation on assessment of riboflavin status using the erythrocyte glutathione reductase activation coefficient assay. British Journal of Nutrition, 2009; 102 (2): 273-8.

[16] Powers HJ, Hill MH, Mushtaq S, Dainty JR, Majsak-Newman G, Williams EA. Correcting a marginal riboflavin deficiency improves hematologic status in young women in the United Kingdom (RIBOFEM). American Journal of Clinical Nutrition, 2011; 93(6):1274-84.

[17] Bates CJ, Mansoor MA, Gregory J, Pentieva K, Prentice A. Correlates of plasma homocysteine, cysteine and cysteinyl-glycine in respondents in the British National Diet and Nutrition Survey of Young People Aged 4-18 Years, and a comparison with the Survey of People Aged 65 Years and Over. British Journal of Nutrition, 2002; 87: 71–79.

[18] Malinow MR, Bostom AG, Krauss RM. Homocyst(e)ine, diet, and cardiovascular diseases: a statement for healthcare professionals from the Nutrition Committee, American Heart Association. Circulation, 1999; 99: 178–182.

[19] Green MH, Green JB 'Dynamics and control of plasma retinol. In: Vitamin A in Health and Disease. Marcel Dekker Inc., (New York, 1994) Pp 119-133.

[20] Department of Health Report on Health and Social Subjects, No. 49. Nutrition and bone health with particular reference to calcium and vitamin D. TSO
(London, 1998).

[21] Bates CJ, Carter GD, Mishra GD, O'Shea D, Jones J, Prentice A. In a population study, can parathyroid hormone aid the definition of adequate vitamin D status? A study of people aged 65 years and over from the British National Diet and Nutrition Survey. Osteoporosis International, 2003; 14: 152-9.

[22] Department of Health. Report on Health and Social Subjects: 46. Nutritional Aspects of Cardiovascular Disease. HMSO (London, 1994).

[23] The British Cardiac Society, British Hyperlipidaemia Association, British Hypertension Society, endorsed by the British Diabetic Association, have issued guidance published in the article 'Joint British recommendations on prevention of coronary heart disease in clinical practice'. Heart, 1998; 80: 1–29.

[24] Friedewald WT, Levy RI, Fredrickson DS. Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. Clinical Chemistry 1972;18: 499-502.

[25] Rayman MP. The importance of selenium to human health. Lancet, 2000; 356: 233–41.