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 and 2 (combined) of the Rolling Programme (2008/2009 – 2009/10)

Supplementary report: Blood analytes

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Notes to text and tables

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

2 A non-response weight has been used for non-response to the nurse visit (with adult and child versions).

3 The data were analysed in SPSS version 14.

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. 'Missing values' for blood results also occur when samples have not been analysed for a particular analyte for a variety of reasons including insufficient volume, a sample is unsuitable for the assay, technical difficulties or an analyte is not measured for a particular age group. 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 for other scientific or public health policy purposes.

[1] http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsStatistics/DH_128166 (accessed 01/08/2011)

Blood analytes

Appendix N Methods of blood analysis and quality control

Blood analytes

Sonja Nicholson, Gerda Pot, Chris Bates and Ann Prentice

1 Introduction

This report includes the results from the analysis of the blood samples taken during the nurse stage (stage two) of Years 1 and 2 of the rolling programme and collected between February 2008 and July 2010. Ethical approval for the NDNS rolling programme was gained from Oxfordshire Research Ethics Committee A. Results for selected analytes for participants aged 11 to 64 years are presented in this report, whilst those for participants aged 1.5 to 10 years and 65 years and over will be reported in the future.

The results in the main report published in July 2011[1] were based on assessment of food consumption over four days and so tell us about diet over a short period. Analysis of blood samples provides an indication of the nutritional status of the population 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 activity 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 of the main report .[1] Appendix H of the main report[1] 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 of the main report.[1] The priority order of analytes for participants aged 1.5 to six years, seven to 15 years and 16 years and over are listed in Appendix L of this report. Appendix M of this report 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 of this report 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 of this report. Appendix Q of the main report[1] details which analytes are reported for Year 1 and Year 2 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[2] and those that will be reported and included in the archived dataset in the future.

1.1 Obtaining the blood sample

All fully productive participants[3] aged 1.5 years and over who were visited by a nurse (1618 individuals) were asked whether they would consent to give a blood sample. 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 six years, 21.1mL from participants aged seven to 15 years and 35.1mL for participants aged 16 years and over. In the case of children aged under 16 years, consent was also sought from a parent or legal guardian. 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 therefore allowed 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 six years, 1 x EDTA, 1 x lithium heparin, 1 x serum gel and 1 x serum monovette tubes were filled. For participants aged seven 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 monovette tubes were filled. For participants aged 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 monovette tubes were filled.

Blood samples were obtained from a total of 811 fully productive participants (50% of those who had a nurse visit), of which results from approximately 160 children aged 11 to 18 years and approximately 360 adults aged 19 to 64 years are provided in this report. Cell sizes 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 of the main report[1] and Appendix M of this report.

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 three years and any participants who were diabetic and did not wish to fast, provided a non-fasting blood sample. Blood samples were not collected from non-diabetic participants aged four years or over who were not willing to fast for an eight hour period prior to venepuncture. The blood sample was collected in the early morning (before midday) due to the majority of participants providing a fasting sample, standardisation of the procedure and to meet the need for processing of the sample within two hours of collection.

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 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 of this report provides further details on the transport, tracking and storage of blood samples.

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 of this report). 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 1-5, other analytes listed in Appendix L of this report were measured. These analytes, further details for which are provided in Appendix Q of the main report are included in the dataset submitted to the UK Data Archive.[2]

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.

To adjust for any bias arising from blood sampling refusals and/or failures, data for the blood analytes in tables 1-5 have been weighted to account for differential non-response to providing a blood sample. Details of the methodology used to weight the data are provided in Chapter 2 and Appendix B of the main report.[1] 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 future years. Notional values were assigned to results below the limit of detection, which were

calculated by dividing the 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).[4]

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 were different to those used in previous NDNS [5,6,7,8] It should be noted that due to small numbers for each sex/age group included in this report, no commentary is given on the upper or lower 2.5th percentiles and the per cent below cut offs for any analyte. However, for some nutrients comments are made when the distribution of data indicates that there is a proportion of the population with low status.

2 Haematology, ferritin and C-reactive protein

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 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 because of menstrual loss. These lower limits for haemoglobin have been set by the World Health Organization (WHO)[9] and are endorsed by the Scientific Advisory Committee for Nutrition (SACN).[10]

The mean haemoglobin concentration for boys aged 11 to 18 years was 143g/L and for men aged 19 to 64 years 150g/L, above the lower limits set by WHO[9] and endorsed by SACN.[10] The mean haemoglobin concentration for girls aged 11 to 18 years was 132g/L and for women aged 19 to 64 years 133g/L, above the lower limits set by WHO[9] and endorsed by SACN.[10] The distribution of the data indicates that there is evidence of iron-deficiency anaemia in a proportion of adult women and older girls.

(**Table 1**)

2.2 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.[11] 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.[9]

The mean haematocrit values for all sex/age groups were above the lower limits set by WHO.[9]

(**Table 1**)

2.3 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 or other chronic disorders.

The lower limits for plasma ferritin below which iron stores are considered to be depleted and the risk of iron-deficiency anaemia increased are 15μg/L for children aged 11 years to 14 years and15μg/L for men and non-pregnant women aged 15 years and over. These lower limits for ferritin have been set by the World Health Organization (WHO)[9] and are endorsed by the Scientific Advisory Committee for Nutrition (SACN).[10]

The mean plasma ferritin value was 43μg/L and 155μg/L for boys aged 11 to 18 years and men aged 19 to 64 years and 29μg/L and 53μg/L for girls aged 11 to 18

years and for women aged 19 to 64 years, the mean ferritin values for all age/sex groups were above the lower limit of the normal range set by WHO[9] and endorsed by SACN[10] for the equivalent age/sex groups. The distribution of the data indicates that there is evidence of low iron stores in a proportion of adult women and older girls.

(**Table 1**)

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

C-reactive protein 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. This is the first time Hs-CRP has been measured in NDNS, since alpha$_1$-antichymotrypsin was used previously as the acute phase marker. High sensitivity C-reactive protein (Hs-CRP) concentrations greater than 3mg/L indicate elevated levels, a threshold provided by the assay kit manufacturer and obtained from Pearson et al., (2003) who stratified Hs-CRP according to risk of cardiovascular disease.[12] Mean serum concentrations of Hs-CRP for girls and boys aged 11 to 18 years were below 3mg/L; whilst those for men and women aged 19 to 64 years exceeded this value.

(**Table 1**)

3 Water-soluble vitamins and plasma total homocysteine

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 free radicals, and helps in the absorption of iron. Plasma vitamin C concentrations reflect recent dietary intakes of vitamin C, with values of less than 11μmol/l indicative of biochemical depletion.[13]

The mean plasma vitamin C concentration for boys aged 11 to 18 years was 57.2μmol/L and for men aged 19 to 64 years 51.5μmol/L and both were above the level indicative of biochemical depletion. The mean plasma vitamin C concentration for girls aged 11 to 18 years was 55.5μmol/L and for women aged 19 to 64 years 56.2μmol/L and both were above the level indicative of biochemical depletion.

(**Table 2**)

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 pernicious anaemia.[14] For adults, the lower level of the normal range for serum vitamin B_{12} concentration is usually taken as 118pmol/L.[15]

The mean serum vitamin B_{12} concentration for boys aged 11 to 18 years was 282pmol/L and for men aged 19 to 64 years 277pmol/L and both were above the lower limit of the normal range. The mean serum vitamin B_{12} concentration for girls aged 11 to 18 years was 276pmol/L and for women aged 19 to 64 years was 278pmol/L and both were above the lower limit of the normal range.

(**Table 2**)

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

Thiamin (vitamin B1) status is measured by the Erythrocyte Transketolase Activation Coefficient (ETKAC). 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. 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.[16]

The mean ETKAC in boys aged 11 to 18 years and also in men aged 19 to 64 years was 1.12; the mean ETKAC in girls aged 11 to 18 years and in women aged 19 to 64 years was 1.11 and 1.10 respectively. None of the sex/age groups had mean ETKAC values indicative of thiamin deficiency.

(**Table 2**)

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

The Erythrocyte Glutathione Reductase Activation Coefficient (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 co-factor 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.[17] 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 may be associated with compromised iron metabolism.[18]

The mean EGRAC in boys aged 11 to 18 years was 1.49 and for men aged 19 to 64 years 1.37, whilst the mean EGRAC in girls aged 11 to 18 years was 1.52 and for women aged 19 to 64 years was 1.41. All sex/age groups had mean EGRAC values greater than those considered to be normal, indicating suboptimal biochemical riboflavin (vitamin B_2) status. The distribution of the data indicates that a substantial proportion of adults and older children have functional riboflavin status values indicative of low status.

(**Table 2**)

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.[14] It should be noted that PLP was not measured in previous NDNS.[5,6,7,8] Previous NDNS surveys measured erythrocyte aspartate aminotransferase activation coefficient (EAATAC) as an index of vitamin B_6 status. An indicative reference range for PLP is 20nmol/L to 202nmol/L.[19]

The mean plasma PLP concentration in boys aged 11 to 18 years was 70.6nmol/L and for men aged 19 to 64 years was 70.9nmol/L, whilst the mean PLP concentration

in girls aged 11 to 18 years was 66.4nmol/L and for women aged 19 to 64 years 55.0nmol/L. Mean plasma PLP concentrations for all age and sex groups were within the lower and upper limits of the reference range for plasma PLP.

(**Table 2**)

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.[20,21]

As shown in Table 2, mean concentrations of homocysteine for males and females aged 11 to 64 years were below 10μmol/L. Boys aged 11 to 18 years and men and aged 19 to 64 years had mean plasma homocysteine concentrations of 8.7μmol/L and 9.7μmol/L respectively. Girls aged 11 to 18 years and women aged 19 to 64 years had mean plasma homocysteine concentrations of 8.6 and 8.8μmol/L.

(**Table 2**)

3.7 Folate

Folate results are not presented in this report. Frozen samples have been stored and are awaiting method development for whole blood and serum folate analysis.

4 Fat-soluble vitamins and carotenoids

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.[22] 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.[19]

The mean plasma retinol concentration for boys aged 11 to 18 years was 1.62μmol/L and for men aged 19 to 64 years 2.31μmol/L. The mean plasma retinol concentration for girls aged 11 to 18 years was 1.63μmol/L and for women aged 19 to 64 years 1.99μmol/L. Thus, the mean levels for all sex/age groups were above the limit of marginal status for retinol.

(**Table 3**)

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 3.

(**Table 3**)

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 3.

(**Table 3**)

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 in the form of 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.[23,24] 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 the table are year-round averages.

Mean 25-OHD concentrations were 44.6nmol/L for boys aged 11 to 18 years and 45.2nmol/L for men aged 19-64 years, whilst mean 25-OHD concentration for girls aged 11 to 18 years was 42.2nmol/L and for women aged 19-64 years 49.5nmol/L. The distribution of the data indicates that there is evidence of low vitamin D status in adults and older children, both male and female.

(**Table 3**)

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, has the highest biological activity and is the most resistant to oxidation. 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.[14]

Mean plasma α-tocopherol concentrations were 22.8μmol/L for boys aged 11 to 18 years and 33.3μmol/L for men aged 19 to 64 years. Mean plasma α-tocopherol concentrations were 25.8μmol/L for girls aged 11 to 18 years and 32.4μmol/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 3 for each sex/age group. (**Table 3**)

5 Blood lipids

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.[25] They are affected by age, genetic and environmental influences, including dietary factors, notably the amount of saturated fatty acids in the diet. 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.[26]

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.[27] 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.

Table 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. Serum total, HDL and LDL cholesterol concentrations for boys aged 11 to 18 years were 4.02, 1.45 and 2.28mmol/L, whilst those for men aged 19 to 64 years were 5.15, 1.32 and 3.15mmol/L respectively. Serum total, HDL and LDL cholesterol concentrations for girls aged 11 to 18 years were 3.91, 1.42 and 2.20mmol/L, whilst those for women aged 19 to 64 years were 5.21, 1.63 and 3.13mmol/L respectively. Mean serum total

cholesterol concentrations in all sex/age groups fell within a category that is associated with minimal risk. The distribution of the data indicates that a proportion of adults had elevated levels of blood lipids, increasing risk of cardiovascular disease.

(**Table 4**)

6 Selenium and zinc

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.[28] There is currently no established normal range for plasma selenium concentration.

Mean plasma selenium concentrations were similar in boys and girls aged 11 to 18 years at 0.90μmol/L and 0.92μmol/L respectively; and men and women aged 19 to 64 years; 1.08 and 1.03μmol/L respectively.

(**Table 5**)

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 including maintaining the aggregation of pre-secretory insulin granules. Zinc also plays a role in major metabolic pathways which contribute to protein, carbohydrate, lipids, nucleic acids and energy metabolism.[14] There is currently no established normal range for plasma zinc concentration.

Mean plasma zinc concentrations were similar across all sex/age groups with concentrations of 15.9μmol/L and 15.5μmol/L in boys and girls aged 11 to 18 years respectively; and 15.8μmol/L and 15.1μmol/L in men and women aged 19 to 64 years respectively.

(**Table 5**)

[1] http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsStatistics/DH_128166 (accessed 01/08/2011)

[2] http://www.data-archive.ac.uk

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

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