



**An Official Statistics Publication for
Scotland**

**National Diet and Nutrition Survey:
Assessment of dietary sodium
Adults (19 to 64 years) in Scotland, 2014**

About Food Standards Scotland

Food Standards Scotland (FSS) is the public sector food body for Scotland. On the 1st April 2015, FSS took on all of the functions previously carried out in Scotland by the Food Standards Agency. FSS exists to ensure that information and advice on food safety and standards, nutrition and labelling is independent, consistent, evidence-based and consumer-focused.

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Notes to text and tables

- 1 The data used in the report have been weighted. The weighting is described in appendices A and C of this report. Unweighted sample sizes (as well as weighted sample sizes – where appropriate) are shown at the foot of each table.
- 2 This survey requires weights to adjust for differences in sample selection and response. The weights adjust for:
 - differential selection probabilities of addresses, households and individuals
 - non-response to the nurse visit
 - non-response to providing a 24-hour urine sample.
- 3 The data in chapters 4 and 5 and appendix C were analysed with the complex survey package R (version 3.0.2).
- 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
 - [] unless stated otherwise data and bases for a variable with a cell size between 30-49 are presented in square brackets. For cell sizes below 30, bases have been presented in square brackets, but data have not been presented.
- 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 deviations 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 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 age/sex 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.

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Executive summary

There is an established relationship between salt intake and risk of high blood pressure.¹ High blood pressure (hypertension) is a risk factor for cardiovascular disease (CVD) and scientific evidence shows that a high salt intake can contribute to the development of elevated blood pressure.

The Scientific Advisory Committee on Nutrition (SACN)^{2,3} recommend a target reduction in the average salt intake of the population to no more than 6 grams per day. This figure has been adopted by the UK Government as the recommended maximum salt intake for adults and children aged 11 years and over. There is also a long standing Scottish Dietary Goal for the average population salt intake in Scotland to reduce to 6 grams of salt per day.

Considerable effort has been made over recent years to raise public awareness of salt intake and health to enable individuals to make informed choices through information (including front-of pack labelling) and education. In parallel action has also focused on reformulation of manufactured foods, because around 75% of the salt we consume comes from manufactured foods.⁴ Voluntary salt (sodium) targets for 85 food categories were first set by the Food Standards Agency (FSA) in 2006.⁵ These targets were revised in 2010, 2011 and 2014 to take account of food industry achievements in salt reduction. The current targets, which have been agreed across the UK, are set for achievement in 2017.⁶ Population representative urinary sodium data for Scotland were collected in 2006,⁷ 2009⁸ and 2014 (this survey) to monitor and evaluate progress.

Estimated salt intake of adults aged 19 to 64 years in Scotland was assessed from the 24-hour urinary sodium excretion of 663 adults, selected to be representative of this section of the population. Urine samples were collected over five months (May to September) in 2014, running concurrently with a similar survey in England. Estimated salt intake was calculated using the equation $17.1 \text{ mmol of sodium} = 1 \text{ g of salt}$ and assumes all sodium was derived from salt. The data were validated as representing daily intake by checking completeness of the urine collections by the para-aminobenzoic acid (PABA) method.

This report presents the results for the latest survey assessment (2014) and analysis of the trend in estimated salt intake since 2006. The trend analysis is based on data for urinary sodium excretion from this survey, two previous stand-alone sodium surveys carried out in 2006 and 2009, and Scotland data from the UK 2008 sodium survey and the National Diet and Nutrition Survey Rolling Programme (NDNS RP) Years 1 to 5 (2008/09-2012/13). These data have been adjusted to take account of biases resulting from changes over time in the laboratory method used for sodium analysis. Sodium excretion and estimated salt intake is provided in line with previous reports, as the arithmetic mean. However, because of the skewed nature of the data, the geometric mean (the mean of the log-transformed data converted back to raw units) was used for the trend analysis and for the comparison with the England survey.

Key findings

- In 2014 the mean estimated salt intake for adults aged 19 to 64 years was 7.8g/day; 8.6g/day for men and 6.9g/day for women. On average 29% higher than the recommended maximum
- The analysis which investigated both gradual trends and step-changes between the period 2006 and 2014 showed a statistically significant downward linear trend in the geometric mean salt intake from 2006 (8.2g/day) to 2014 (7.1g/day). This 1.1g difference⁹ equates to a relative reduction in mean estimated salt intake of approximately 13%
- There were no statistically significant differences between the salt intake for adults in Scotland and England for the 2014 surveys for all adults combined and when split by sex. The results showed that in 2014 the geometric mean salt intake in Scotland (7.1g/day) was similar to that in England (7.2g/day) for males and females combined

1. Introduction

This survey provides data to establish progress towards meeting the Scottish Dietary Goal for the average population salt intake in Scotland to reduce to 6g per day (g/day)^{10,11} which is based on advice from the Scientific Advisory Committee on Nutrition (SACN) in 2003.² It builds on the series of previous urinary sodium excretion surveys reporting estimated salt intake in the general adult population (19 to 64 years) in Scotland and other United Kingdom (UK) countries.^{7,8,12,13,14}

Dietary salt intake can be assessed by measuring sodium excretion in urine. Salt is the predominant source of sodium in the UK diet and estimation of intake from excretion is more reliable than through dietary assessment because it is difficult to quantify discretionary salt used in cooking and at the table. A 24-hour urine collection method, validated by the para-aminobenzoic acid (PABA) method (see chapter 2, section 2.6) was used for this survey, and is consistent with previous UK sodium studies. This method is accepted as being the most reliable method for assessing estimated salt intake in the population. The level of sodium in urine fluctuates according to what was eaten at the last meal and how much fluid an individual has drunk, making assessments based on a 24-hour collection more accurate than a single spot sample.²

A sample size of 600 complete 24-hour urine collections, representative of the population aged 19 to 64 years living in Scotland, was required to detect a difference of 0.5g of salt intake compared with the previous survey carried out in Scotland in 2009 (calculated from the standard error in that survey).⁸

This report presents a trend analysis of estimated salt intake over time for Scotland. Based on adjusted data for urinary sodium excretion the analysis has taken into account changes in laboratory methods over time and has included Scotland-specific data from the National Diet and Nutrition Survey Rolling Programme (NDNS RP) Years 1 to 5 (2008/09-2012/13) and the current survey. The trend analysis considered both gradual and step changes in trend through the survey periods from 2006 to 2014.

1.1 Background

There is an established relationship between salt intake and risk of high blood pressure.¹ High blood pressure (hypertension) is a risk factor for cardiovascular disease (CVD) and scientific evidence shows that a high salt intake can contribute to the development of elevated blood pressure.² CVD is a major cause of morbidity and mortality in the UK and worldwide. The British Heart Foundation (BHF) in 2015 estimated that CVD causes 155,000 deaths in the UK

and costs the UK economy £19 billion annually.¹⁵ Dietary modification is a major component in the preventative strategy to reduce the risk of CVD.

Since the early 1990s the UK government has recommended a reduction in salt intake in the interest of public health. In 1994, the Committee on Medical Aspects of Food and Nutrition Policy's (COMA) cardiovascular review group recommended that population average salt intake should be gradually reduced further to a daily average of 6g/day or less for adults.¹⁶ In 2003 SACN published its Report on Salt and Health which endorsed COMA's recommendation for 6g/day. The SACN report noted a reduction in the salt content of processed foods would be necessary to achieve the recommendation.²

In Scotland in 1993, there was a recommendation that the average sodium intake should reduce to 100mmol per day (equivalent of 6g). This recommendation was accepted in the Scottish Executive's "Eating for Health: Diet Action Plan for Scotland" (SDAP) which in 1996 outlined the original Scottish dietary targets.¹⁷ In 2013, revised Dietary Goals for Scotland (SDGs) were published,¹¹ and still encompass a goal for the average population salt intake to reduce to 6g/day.

Considerable effort has been made over recent years to raise public awareness of salt intake and health to enable individuals to make informed choices through information (including front-of pack labelling) and education. Action has also focused on reformulation of manufactured foods, because around 75% of the salt we consume comes from manufactured foods.⁴ To support this aim, voluntary salt (sodium) targets for 85 food categories were first published by the Food Standards Agency (FSA) in 2006. These targets were revised in 2009 and 2011 to take account of food industry achievements in salt reduction. The current targets, which have been agreed across the UK, were set in 2014 for achievement in 2017. These targets outline salt reductions for 76 food categories that contribute the most to the population's salt intake.⁶ Major retailers, manufacturers and eating out businesses are now working towards these targets.

Supporting Healthy Choices,¹⁸ the Scottish Government (SG) and Food Standards Scotland (FSS) voluntary framework (2014) for the food, retail and catering industry, includes a commitment to reduce the salt content of manufactured foods, in line with the UK 2017 salt targets. Scotland also has a Healthy Living Award scheme, for those in the catering sector that provide food, which supports the achievement of the SDGs, including salt reduction.¹⁹

In Scotland, advice to consumers over recent years has been to 'check the label' and choose products which are lower in salt. Previous UK targeted public awareness campaigns by the FSA aimed to inform the UK population about health risks associated with high salt consumption.²⁰ These campaigns have advised individuals to limit their salt consumption to no more than 6g/day (less for children). The Eat Better Feel Better²¹ campaign in Scotland

focuses on helping the population eat healthily through the provision of recipes and associated information.

Prior to this survey (carried out in 2014), there have been two main urinary sodium surveys using 24-hour collections, including representative samples of adults aged 19 to 64 years in Scotland. The first survey carried out in 2006⁷ included 442 complete collections, and the second carried out in 2009⁸ included 702 complete collections. A total of 266 complete collections from adults aged 19 to 64 years in Scotland were also obtained from the NDNS RP 2008/09-2012/13 (with 11 complete collections from the NDNS RP 2012/13).^{22,23} In addition a UK survey carried out in 2008 included 58 complete 24-hour collections from participants in Scotland which have been included in the trend analysis.

There were a number of methodological differences from survey to survey in relation to: a) the laboratory analytical methods for measuring sodium in urine, b) the methods of defining “complete” urine collections for inclusion in the data analysis and c) the sample design such as stratification and clustering. In this report the effect of changing methodologies over time in the analysis of urinary sodium has been accounted for retrospectively as far as possible in order to allow combination of data from the different surveys and hence improve the reliability of the conclusions. This means that the published results for the survey in 2009 and the NDNS RP Years 1 to 4 (2008/09 – 2011/12) in Scotland have been altered, and as they are now different from those originally published, the data tables from the 2009 sodium survey and the NDNS RP report and the associated datasets on the UK data archive will be updated following publication of this report.

1.2 Aims of the survey

The aims of the survey were to:

- assess urinary sodium excretion in adults aged 19 to 64 years living in Scotland, by collecting and analysing 24-hour urine samples in a representative sample of the population
- estimate dietary salt intakes (g/day) from urinary sodium excretion
- conduct an analysis of trends in estimated salt intake (g/day) in Scotland based on data collected from the urinary sodium surveys carried out in 2006, 2009 and this survey (2014) and Scotland data from the UK 2008 sodium survey and the NDNS RP collected between 2008/09 and 2012/13
- statistically compare estimated salt intake in Scotland with the estimate for the concurrent survey in England²⁴

Ethical approval for the survey was granted by the Cambridge South NRES Committee (Ref. No. 13/EE/0016).

The survey was carried out by NatCen Social Research (NatCen) and MRC Human Nutrition Research (HNR) and was funded by FSA Scotland.²⁵

2. Methodology

2.1 Sample design

The aim was to obtain, over a five-month period (May to September 2014), 600 complete 24-hour urine collections representative of the population of Scotland aged 19 to 64 years. The survey was designed to be:

- representative of the population aged 19 to 64 years living in Scotland, and
- able to detect a difference of 0.5g of salt intake compared with the previous survey in Scotland carried out in 2009 (calculated from the standard error in that survey).⁸

The Postcode Address File²⁶ was used to sample postcodes that were representative of the population. Forty-five postcode sectors were selected and within these, a random sample of landline telephone numbers was drawn using Random Digit Dialling (RDD).²⁷

The participants were recruited by NatCen's Telephone Unit (TU) interviewers. Within each household a maximum of two people aged 19 to 64 years were eligible to take part in the survey. Where there were more than two eligible adults in a household, two were randomly selected. Those living in institutions and females who were pregnant or breastfeeding were not eligible to take part in the survey.

2.2 Participant recruitment

NatCen's TU interviewers attempted to make contact with the households of the generated telephone numbers and when successful, followed a Computer Assisted Telephone Interviewing (CATI) script to introduce the survey, check the eligibility of household members and attempt to recruit up to two participants per household. The TU interviewer then sought agreement for a nurse to contact the selected participant(s) in order to arrange a home visit for collection of the 24-hour urine sample(s).

The nurse made initial contact with the participant(s) via telephone, after which they sent a letter confirming details of the appointment date and time to the participant(s). The nurse then visited participating households twice: the first visit to explain the collection protocol and provide the participant(s) with the collection equipment and the second visit to take a subsample of the urine collection.

Each participant who provided a urine sample was given a £15 gift card as a token of appreciation for their participation in the survey.

2.3 Urine collection protocol

After obtaining written consent (see appendix D), the nurse instructed participants in the 24-hour urine protocol. They were asked to collect all urine during a 24-hour period starting from the second morning urine pass of the 24-hour collection day, and ending after the first urine passed the following morning. The nurse used the Computer Assisted Personal Interview (CAPI) programme to randomly allocate a day of collection for the participant(s). If the allocated date was unsuitable, CAPI would allocate an alternative start day. Nurses would discuss the allocation of the collection day with each participant emphasising the importance of the representativeness of the survey across the whole week. However, in order to maximise response, participants were allowed to collect their sample on the day of their choice. Women were instructed to collect their urine on non-period days.

Participants were provided with the necessary equipment to do the 24-hour collection and were asked to take three PABA tablets at evenly spaced intervals throughout the day of the collection. Participants were still eligible to take part if they were willing to carry out the 24-hour urine collection but did not want to (or could not) take PABA. During the collection period participants were required to record the time they took the PABA tablets, the start and finish times of their urine collection, any missed urine passes, and any medication or supplements taken during the collection period (see appendices A and D for more details).

The nurse revisited participants on the day or the day after the 24-hour urine collection was completed. This ensured that the sample did not deteriorate before reaching HNR for analysis. At this second visit the nurse weighed the entire urine collection using Salter Breknell ElectroSamson digital handheld scales and (after shaking to mix thoroughly) collected two samples from the total 24-hour urine sample and disposed of the remaining urine and equipment (see appendix A, section A.7 for more details).

The nurse then packaged and posted the samples and paperwork to the laboratory at HNR.

2.4 The household questionnaire

During the second visit the nurse also asked a variety of household questions and recorded the responses in CAPI. Participants were asked about household income (including earnings, pension and benefits), occupational status (including paid work, career breaks, seasonal employment, unemployment and retirement) and housing tenure.

2.5 Urinary sodium measurement and analytical laboratory procedures

Measurement of urinary sodium was carried out at HNR using an ion selective electrode (ISE) on the Siemens Dimension® Xpand clinical chemistry system with the QuikLYTE® module. The 24-hour excretion was determined by multiplying urinary concentration by 24-hour volume (determined by weighing the collection, see appendix A, section A.7 for more details). This was

then multiplied by a method-specific factor, derived from method comparison studies, to enhance accuracy and enable comparison with previous urinary sodium survey data obtained with different methods. Details of the analytical procedures are given in appendix B.

Laboratory methods for assessment of urinary sodium concentration have evolved over time and consequently different surveys have used different methods. Historically the most common method was flame photometry. This method has since been superseded by ISE methods; the NDNS RP from 2008/09 and urinary sodium surveys from 2011 have used ISE technology on the Siemens Dimension Xpand for urinary sodium measurement. The sodium assays for all surveys except 2006 were performed by HNR.

HNR has carried out comparison studies between the methods to derive factors which can be applied to urinary sodium concentrations measured by each method so that the results over time are all directly comparable, irrespective of the instrument and analytical method used. This facilitates a much more accurate description of salt intake trends (see appendix B, section B.2.1).

Urinary sodium measurement in the 2006 survey was conducted by The Doctors' Laboratory, London (TDL), using the Roche P module (ISE technology). No direct comparison study has been performed between this instrument and those used at HNR; however the external quality assessment data provided by TDL covering the relevant time period suggest that a factor of 1.0 was appropriate for this survey.

2.6 Assessment of completeness of collection

Completeness of 24-hour urine collections was assessed in all of the surveys using the PABA method,²⁸ with modifications as described below and in appendix B (section B.2.2). Where participants reported taking the three 80mg PABA tablets at appropriate intervals, 24-hour urine collections were considered to be complete if they contained between 70% and 104% of the PABA, i.e. 168 to 250 mg²⁹ (further details are provided in appendix B).

Urine collections with a PABA recovery under 70% were considered incomplete, whilst those with a PABA recovery greater than 104% were considered unfeasibly high and therefore unreliable. Complete collections (those with a PABA recovery of between 70% and 104% of the PABA) were included in the results, whilst collections deemed incomplete or unreliable were excluded.

Individuals who elected not to take PABA but recorded they had completed a 24-hour urine collection were also included; i.e. individuals who recorded start and finish times within one hour of a 24-hour collection period (i.e. recorded urine collected between 23 to 25 hours) were deemed to have a complete 24-hour collection. In addition participants who elected to take PABA but reported that they did not take all three PABA tablets yet still completed a 24-hour urine collection were also included.

PABA was used as a marker of complete excretion for all surveys from 2006 onwards. However, the criteria by which 24-hour urine collections were selected for inclusion in the dataset have evolved over time. Completeness of 24-hour urine collections from participants who declined to take PABA was assessed on the basis of the participant's claim in some of the surveys (see tables B and C in chapter 5 for more details).

Analytical methods for measuring PABA have also evolved. The analytical method for PABA was originally colorimetry with high performance liquid chromatography (HPLC) reanalysis of urines containing unfeasibly high excretion, and "correction" of results from urines in which PABA excretion indicated marginal incompleteness. From late 2010 onwards HNR moved to measure PABA by HPLC only as this is a more robust method and is not subject to interference by azo compounds, which include some medications. The PABA excretion consistent with a complete 24-hour urine collection was re-validated based on HPLC and on colorimetric analysis. All urine collections for the 2014 Scotland sodium survey (this current survey) and the NDNS RP that were classified as incomplete by PABA excretion were excluded from the dataset; no correction factors were used.

Further detail of the laboratory analytical methodology used in this survey can be found in appendix B.

2.7 Considerations for data interpretation

The following should be borne in mind when interpreting the data:

- analyses were based on each participant's sodium excretion during a single 24-hour period and assumed that the 24-hour collections defined as "useable" contained all urine passed during the collection period
- the estimated salt intake distributions show a very wide scatter (approximately five-fold difference between the lower and upper 2.5 percentiles)
- a single 24-hour urine collection does not represent a typical sodium excretion for an individual participant. Sodium excretion varies day to day depending not only on intake but also on hormonal and other physiological influences. Each urine collection contributing to a survey provides a data point; taken together they describe the population distribution
- there were a number of methodological differences from survey to survey in relation to: a) the laboratory analytical methods for measuring sodium in urine, b) the methods of defining "complete" urine collections for inclusion in the data analysis and c) the sample design such as stratification and clustering. In this report the effect of changing methodologies over time in the analysis of urinary sodium has been accounted for

retrospectively as far as possible in the trend analysis in order to allow combination of data from the different surveys and hence improve the reliability of the conclusion. This process was relatively straightforward and the analytical factors adopted were experimentally verified. However, there were also differences over time in survey design and in the identification of 24-hour collections as “complete” which are more complex and difficult to harmonise. Therefore, it is likely that some inherent variation may remain between data collected in the different surveys that cannot be accounted for

- as in the previous surveys, the number of people in the youngest age group (19 to 34 years) providing 24-hour urine collections in 2014 was low, highlighting the challenges in involving younger adults in 24-hour urine studies. This may also have been influenced by the household/participant selection method which included only households with landline telephones

3. Response and Weighting

Information about response, the useability of the 24-hour urines collected (and urine sample collection days) is presented below.

3.1 RDD and nurse response

Of 11,412 telephone numbers attempted by NatCen's TU interviewers 88% (10,065) were useable. Of these, 21% (2085) were households that had at least one eligible adult aged 19 to 64 years who agreed to the telephone interview (34% were deemed ineligible as no one within this age range was resident), 32% refused the telephone interview and 14% were unproductive for another reason).

In total 1,063 households, containing 975 individuals eligible for the sample, were issued to the nurses.

(Table 1)

Of the 975 individuals issued to nurses, 94% (916) of individuals were visited by a nurse and 88% (857) provided a 24-hour urine collection. These response rates were very similar to those achieved in the concurrent survey in England where 92% of individuals were visited by a nurse and 86% provided a collection.

(Table 2)

3.2 Number of useable urine collections

In total, 857 24-hour urines were collected. However, six were lost in transit and not received by the HNR laboratory. A further six were from participants who were outside the 19 to 64 years age group or who had provided an incomplete collection sheet or a consent form with discrepancies and so their samples were not suitable for analysis.

Therefore, 845 urines, from 364 men and 481 women, were processed by the HNR laboratory. Of these, 78% (663) were classified as 'complete' and 22% (182) were classified as 'incomplete or unreliable'. This was higher than the percentage of complete collections provided in the 2014 sodium survey in England (70%) and was slightly higher than the percentage of complete urine collections provided in the 2009 sodium survey in Scotland (75%) (see table B of this report and table A of the England report for more details of the completeness criteria for each survey). Of the urine collections included in the final analysis, 44% (294/663) were from men and 56% (369/663) were from women.

The majority (167) of the 'incomplete or unreliable' urine collections were excluded from the dataset on the basis of PABA excretion being outside the range of 70-104% (where three PABA tablets had been taken). A further 15 (where three PABA tablets were not taken) were excluded on the basis of the participant's record. The percentage of 'incomplete or unreliable' urine collections provided in this survey (22%) was lower than that in the concurrent survey in England (30%) and was slightly lower than the percentage of 'incomplete or unreliable' urine collections provided in the 2009 sodium survey in Scotland (25%).

(Table 3)

Of the urine collections provided by men 81% (294/364) were classified as complete and 19% (70/364) were classified as 'incomplete or unreliable'. Of the urine collections provided by women 77% were classified as complete (369/481) and 23% (112/481) were classified as 'incomplete or unreliable'. The sex profile of participants included in the analysis was significantly different ($p < 0.05$) from the participants excluded from the analysis.

The age of participants was not significantly different between the included and excluded sample. The mean age for men in the included sample was 50.9 years and 48.2 years in the excluded sample. For women the mean age of those in the included sample was 49.8 years and 50.0 years in the excluded sample. These data are similar to the 2014 sodium survey in England and previous urinary sodium surveys.

(Tables 3 and 5)

3.3 Urine collection days

Start days for 24-hour urine collections were randomly allocated by CAPI in order to spread sampling throughout the week and avoid over-representation of weekend days when diet may be different from weekdays. Nurses encouraged participants to follow this allocation but in order to maximise response they were allowed to choose a different start day.

Overall, 55% of urines (363/663) were collected from Monday to Friday, and 45% (300/663) were collected at the weekend, so samples collected at the weekend are over-represented in the dataset, as for previous surveys. These data are similar to the 2014 sodium survey in England.

(Table 4)

3.4 Weighting

The data were 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 bias³⁰ (see appendix A for detail of the weighting strategy).

4. Results

4.1 Estimated salt intake

The main aim of the 24-hour urine collection analysis was to estimate the mean and population distribution of estimated salt intake (g/day) in Scotland among adults aged 19 to 64 years. In line with the previous urinary sodium surveys^{7,12,13,8,14} salt intake was calculated using the equation:

$$17.1 \text{ mmol of sodium} = 1 \text{ g of salt}$$

This assumes that dietary intake of sodium is equal to the 24-hour sodium output in urine, and that all sodium in the diet comes from salt.¹⁴

Prior to applying this equation, the urinary sodium excretion data were adjusted using a method-specific equation in order to improve accuracy and to enable comparison across the different datasets which have used different laboratory analytical methods (for information on derivation of the correction factor see appendix B, section B.2.1). This means that the results taken from the previously published survey in 2009 and the NDNS RP Years 1 to 4 (2008/09 – 2011/12) in Scotland have been altered and are different from those originally published (data tables from prior sodium survey and NDNS RP reports and associated datasets on the UK data archive will be updated following the publication of this report).

Table 6 provides mean urinary sodium excretion by sex/age group expressed as mmol/24hr and table 7 shows the cumulative percentage distribution of urinary sodium excretion. Table 8 provides mean estimated salt intake by sex/age group expressed as g/day and table 9 shows the cumulative percentage distribution of estimated salt intake.

Mean urinary sodium excretion for adults was 133mmol/24hr; 148mmol/24hr for men and 118mmol/24hr for women.

(Table 6)

The mean estimated salt intake for adults aged 19 to 64 years in 2014 was 7.8g/day, which is 29% greater than the SACN recommendation of a population average of no more than 6g/day.^{2,3} Men had a mean daily intake of 8.6g/day, and women had a mean daily intake of 6.9g/day. As in the past, there was a wide distribution in estimated salt intake and some urine collections contained a large amount of salt. This skewed distribution may affect the arithmetic mean disproportionately, making the median a more robust estimate of the overall population status. The median estimated salt intake for the adult population was 7.3g/day (21% higher than the SACN recommended maximum); 7.8g/day for men, 6.5g/day for women).

(Table 8)

There was a wide distribution of estimated salt intakes. Overall, 70% of the estimates were higher than the population target maximum of 6g/day.³¹

(Table 9)

4.2 Previous sodium surveys in Scotland and comparison of estimated salt intake in Scotland and England 2014 sodium surveys

Table A shows descriptive statistics of estimated salt intake (g/day) in previous sodium surveys in Scotland in 2006 and 2009, the current assessment in Scotland and in England in 2014. Data have been amended by applying appropriate method-specific factors as above.

Comparison of estimated salt intake in Scotland and England in 2014 used log-transformed data and geometric means^{9,32} because the distribution is skewed. Table 12 shows that there were no statistically significant differences between the salt intake for adults in Scotland and England for the 2014 surveys for males and females separately or combined. The results showed that the geometric mean estimated salt intake in Scotland (7.1g/day) was similar to that in England (7.2g/day) for males and females combined in 2014.

(Table 12)

Table A: Estimated salt intake (g/day) in Scotland (2006, 2008/09-2009/10, 2010/11-2012/13 and 2014) and England (2014), by sex

Estimated salt intake (g/day) ^a	Survey				
	Scotland 2006	Scotland 2008- 2009/10	Scotland 2010/11- 2012/13	Scotland 2014	England 2014
Men					
Geometric mean	9.7	9.5	9.4	8.0	8.5
Arithmetic mean	10.5	10.3	10.2	8.6	9.1
SE of the geometric mean	0.39	0.24	0.66	0.24	0.29
SE of the arithmetic mean	0.42	0.30	0.72	0.28	0.33
Women					
Geometric mean	6.8	7.4	5.4	6.4	6.2
Arithmetic mean	7.5	7.9	6.4	6.9	6.8
SE of the geometric mean	0.30	0.18	0.78	0.24	0.20
SE of the arithmetic mean	0.31	0.18	0.57	0.24	0.24
All					
Geometric mean	8.2	8.4	7.0	7.1	7.2
Arithmetic mean	9.0	9.1	8.1	7.8	8.0
SE of the geometric mean	0.28	0.15	0.65	0.21	0.20
SE of the arithmetic mean	0.30	0.18	0.49	0.21	0.25
Bases (weighted)					
<i>Men</i>	224	352	30	322	340
<i>Women</i>	206	371	36	336	327
<i>All</i>	430	723	66	657	667
Bases (unweighted)					
<i>Men</i>	195	402	62	294	298
<i>Women</i>	247	472	90	369	391
<i>All</i>	442	874	152	663	689

^a Estimated using the equation 17.1mmol of sodium = 1g of salt.

5. Estimated salt intake trend analysis (2006 – 2014)

5.1 Introduction

The objective of the trend analysis was to estimate the change in salt intake in Scotland, between 2006, the first assessment after salt reduction work began, and the most recent assessment in 2014 and to consider whether there had been any step-changes between survey years and/or gradual change over time. Additional information is provided in appendix C of this report.

Care should be taken in interpreting population statistics collected over time. Improvements in data collection and analytical methods may mean that previous interpretations are no longer valid, and must be reappraised. Key considerations for performing a trend analysis are the comparability of data available at each time point and the comparability of different methods used in the various surveys. Factors considered in the present analysis include:

- accuracy/comparability of laboratory methods used over time for the measurement of urinary sodium concentration
- identification of complete/incomplete 24-hour urine collections
- complex sample design (sample weights, clustering and stratification)
- comparability of data for Scotland at different time points

The trend analysis is based on data for Scotland only and takes into account all the individual data points instead of survey means. It includes Scotland data from the UK 2008 sodium survey and NDNS RP Years 1 to 5 (2008/09-2012/13) and the current 2014 survey.

Urinary sodium concentrations from current and previous surveys using different analytical methods have been adjusted using factors to take account of method-specific analytical biases so that the results are comparable between surveys (see chapter 2, section 2.5).

5.2 Data preparation and methodological considerations

This section describes the sources of urinary sodium excretion data and summarises the methodological considerations undertaken to ensure a valid combination and interpretation of data.

Table B provides a description of the number of complete collections and sample design for each survey included in the trend analysis (2006-2014). The 2000/01 NDNS of adults aged 19 to 64 years is included for reference, but was not included in the trend analysis (see bullet-points at the end of this section for more information).

For historical and reporting purposes, arithmetic means have been provided. Due to the skewed nature of the data, geometric means have been calculated (by transforming the data on a natural logarithmic scale) and used for statistical analyses to evaluate relative changes in the data (e.g. between years or groups) and minimize bias from the skewed data.

Table B: Sources of Scotland urinary sodium excretion data by year

Survey ^a	Sample size of included (complete/corrected) collections ^a	PABA method (criteria for inclusion/exclusion of 24-hour urine collections) ^b	Sample design	Group that this survey data was placed in for trend analysis
NDNS 19-64y 2000/01	Scotland = 97	Not used ^c .	Stratified and clustered	(N/A)
Scotland Sodium Survey 2006	442	PABA method performed by MRC Dunn Nutrition Unit (colorimetry). Samples with: 85-110% PABA recovery considered complete 70-84% recovery included after applying a correction equation. Under 70% recovery considered incomplete and excluded. Over 110% recovery considered artificially high and reanalysed by HPLC – HPLC 75-77% included after correction, below 75% and high results excluded.	Stratified and clustered ^d	1
UK Sodium Survey 2008	Scotland = 58	PABA method performed by MRC Dunn Nutrition Unit (colorimetry). Samples with: 85-110% PABA recovery considered complete. 70-84% recovery included after applying a correction equation. Under 70% incomplete and excluded. Over 110% recovery reanalysed by HPLC – HPLC below 75% and above 110% excluded.	Stratified and clustered	2
NDNS RP Y1 2008/09 ^e	Scotland = 57	85-119% (colorimetry) complete. Over 119% considered artificially high and reanalysed by HPLC.	Stratified and clustered	2
NDNS RP Y2 2009/10 ^e	Scotland = 57	Under 85% (colorimetry) incomplete and excluded. No correction factors applied Samples with no PABA but collection time of 23-25 hours with no missed collections were included.		
Scotland Sodium Survey 2009	702	85-110% (colorimetry) complete. 70-84% (colorimetry) included after correction. Under 70% incomplete and excluded. Over 110% considered artificially high and reanalysed by HPLC – HPLC 75-77% included after correction, below 75% and high results excluded.	Stratified and clustered	2

Table B (continued): Sources of Scotland urinary sodium excretion data by year

Survey ^a	Sample size of included (complete/corrected) collections ^a	PABA method (criteria for inclusion/exclusion of 24-hour urine collections) ^b	Sample design	Group that this survey data was in for trend analysis
NDNS RP Y3 2010/11 ^e	Scotland = 54	70%-104% PABA (HPLC) complete. Below 70% (HPLC) incomplete and excluded. No correction factors applied. Samples with no PABA but collection time of 23-25 hours with no missed collections were included.	Stratified and clustered	3
NDNS RP Y4 2011/12 ^e	Scotland = 87			
NDNS RP Y5 2012/13 ^f	Scotland = 11			
Scotland Sodium Survey 2014	663	70%-104% PABA (HPLC) Below 70% (HPLC) incomplete and excluded. No correction factors applied. Samples with no PABA but collection time of 23-25 hours with no missed collections included.	Stratified and clustered	4

^a Where source survey was UK, only Scotland data have been provided and included in the analysis.

^b Where not stated, analysis was performed by MRC HNR.

^c Use of PABA was discontinued partway through wave 1 due to a suspected allergic response in one participant, however, this was subsequently found to be unrelated to PABA.

^d The 442 participants of the 2006 Scotland Sodium Survey (SSS 2006) were recruited from a follow-up of the Scottish Health Survey 2003 (SHS 2003) and Random Digit Dialing (RDD). The 350 participants from SHS 2003 had a complex survey design, and hence the SSS 2006 utilized the same strata and cluster information. For the 92 participants selected through RDD, 61 of them had available associated strata and cluster. For the remaining 31 of the 92 RDD participants which belonged to a 'lonely PSU' (where only one household was represented in that PSU), a nearest neighbour approach was used to assign them to their nearest postcode/cluster.

^e In the NDNS RP there was a general sample population boost in Scotland between 2008/09 and 2011/12 (Years 1-4).

^f 24-hour urine was only measured as part of the main NDNS RP in Years 1-5.

Laboratory methods for the measurement of sodium have evolved over time and different surveys have consequently used different methods (see table C). Sodium excretion data used to estimate salt intakes were multiplied by the appropriate method-specific factor for each survey in order to adjust for analytical biases and enable comparison of data obtained with different laboratory methods at different times (see table C). Application of these factors has resulted in slightly higher estimates in samples from the more recent surveys measured by ISE technology. Further details are provided in chapter 2, section 2.5 and in appendix B, section B.2.1.

Table C: Laboratory analytical methods used; selection of useable urine collections

Survey ^a	Method of sodium analysis	Method-specific factor	Identification of complete samples:	Group that this survey data was put in for trend analysis
NDNS 19-64y 2000/01	Flame photometer (IL 943) at HNR	0.952	Participant claim substantiated by urine:plasma creatinine ratio assessment ^b	(N/A) These data were not included in the trend analysis
Scotland Sodium Survey 2006	ISE (Roche/Hitachi) at The Doctors Laboratory (TDL)	1.0 ^c	PABA (colorimetry / HPLC)	1
UK Sodium Survey 2008	Flame photometer (IL 943) at HNR	0.952	PABA (colorimetry / HPLC)	2
NDNS RP Y1 2008/09 Y2 2009/10	ISE (Siemens Dimension Xpand) at HNR	1.052	PABA (colorimetry / HPLC) or participant claim	2
Scotland Sodium Survey 2009	ISE (Siemens Dimension Xpand) at HNR	1.052	PABA (colorimetry/ HPLC)	2
NDNS RP Y3 2010/11 Y4 2011/12 Y5 2012/13	ISE (Siemens Dimension Xpand) at HNR	1.052	PABA (HPLC) or participant claim	3
Scotland Sodium Survey 2014	ISE (Siemens Dimension Xpand) at HNR	1.052	PABA (HPLC) or participant claim	4

^a Where the source survey was UK, Scotland only data have been included in the analysis.

^b Use of PABA was discontinued partway through wave 1 due to a suspected allergic response in one participant, however, this was subsequently found to be unrelated to PABA.

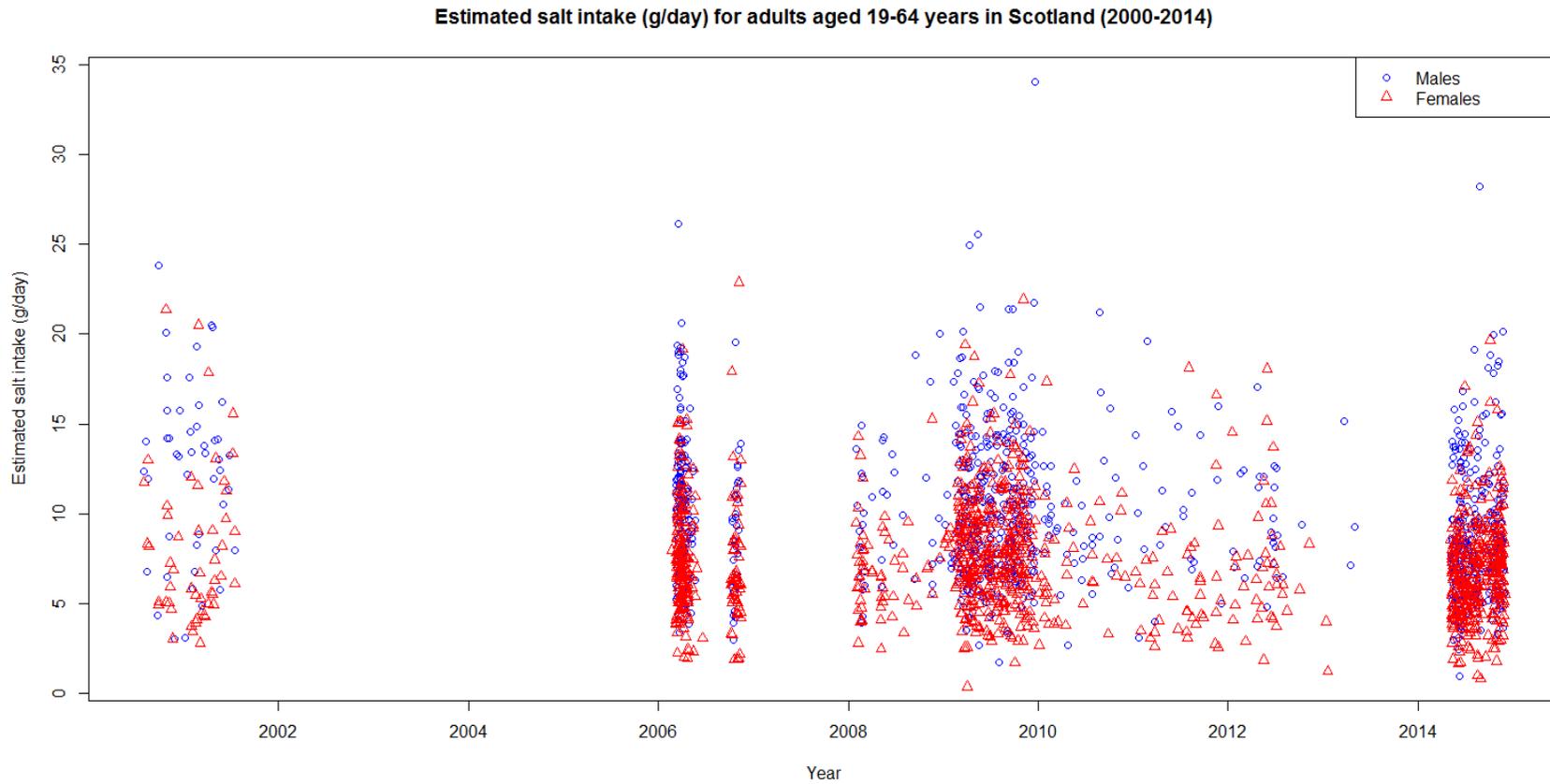
^c Factor determined from contemporaneous external quality assessment, not from comparison survey.

Only 24-hour urine collections regarded as complete were included in the trend analysis. The definition of “complete” used in each survey was specific to that survey; no attempt has been made here to standardise the definition. The number and characteristics of individuals with incomplete urine collections were explored to check that there was no substantial loss of information resulted from their exclusion and that there were no patterns in the characteristics of excluded individuals which needed to be considered in the analysis. Additionally, for the UK 2008 survey, the representativeness of the Scotland only data included in the trend analysis was checked. Where the source survey was UK, only Scotland data have been included in the analysis.

The scatterplot of the available survey data in figure 5.1 demonstrates overlapping time points between surveys (date of collection). For information, data collected in 2000/01 as part of the NDNS of adults aged 19 to 64 years (from Scotland only) are displayed in figure 5.1; but these data were not included in the trend analysis in this report for the following reasons:

- no substantial changes were expected between 2000/01 and 2006 because 2006 was when the work with food manufacturers to encourage product reformulation started, although awareness-raising publicity campaigns to the public had started earlier
- 24-hour collections were not verified using PABA recovery in 2000/01. As indicated in the 2000/01 report (see section 4.2.1 of that report) this probably caused an underestimate in the 24-hour urine results of that survey. This is not quantifiable and reduces confidence in the 2000/01 data
- the time interval between 2000/01 and 2006 is large in comparison with the remaining time intervals and therefore this time point, compromised by the insecurity detailed in the preceding point, would exert a disproportionately large influence in the trend analysis
- the first main survey of salt intakes in Scotland which was designed to provide data which was representative of the population in Scotland, took place in 2006. UK surveys prior to 2006 did not include sufficient numbers of participants to provide representative data for Scotland

Figure 5.1: Scatterplot of individual estimated salt intake (g/day) in Scotland, by sex (2000/01-2014)^{a,b}



^aData collected in 2000/01 are displayed in the figure, but these data have not been included in the trend analysis because they do not provide an appropriate baseline for the target trend analysis (2006-2014).

^b Where a UK survey has been used, data presented are for Scotland only.

Following inspection of the plot shown in figure 5.1, the following combinations of individual Scotland data by year were grouped in the trend analysis (as indicated in tables B and C):

- Group 1: Scotland 2006
- Group 2: UK 2008, Scotland 2009, and NDNS Y1 (2008/09) and Y2 (2009/10)
- Group 3: NDNS Y3 (2010/11), Y4 (2011/12) and Y5 (2012/13)
- Group 4: Scotland 2014 (this survey)

5.3 Sample design

For the purposes of the trend analysis; all available Scotland urinary sodium data from surveys between 2006 and 2014 were considered. Each of the surveys had a complex sample design, detailed in table B, and for which their stratification and clustering were taken into account in the analysis. Certain surveys were combined according to survey periods due to overlapping collection time points. To combine the surveys and account for the complex sample design, the sampling weights for each survey were combined using the 'combining sample weights' approach detailed in O'Muircheartaigh et al. (2002).³³ Additional information regarding the trend analysis methodology is provided in appendix C.

5.4 Trend analysis

The availability of sodium excretion data by survey is summarised in table B.³⁴ Tables B and C provide details on the laboratory and complex sample design methods used in each survey. The objective for the trend analysis was to assess the change in estimated salt intake in Scotland between 2006 and 2014.

Prior to carrying out statistical analysis to assess trend, distributions and outliers of estimated salt intake were investigated through boxplots and histograms for men and women aged 19 to 64 years (see appendix C). The initial exploratory data analysis showed the distribution of estimated salt intake to be positively skewed; hence a natural logarithmic transformation was applied. Such scaling or transformation of data reduces skewness resulting in a more symmetric distribution of the data. The mean of the log-transformed data converted back to raw units equates to the geometric mean,³⁵ providing a relative measure that is comparable, easily interpretable, and the most accurate estimate of a percent change. As an illustration, suppose that between hypothetical time points 1 and 2, there was an observed difference of 0.032. The exact percent difference would be given by $100(e^{diff}-1)\% = 100(e^{0.032}-1)\% = 3.25\%$, and hence the (mean) percent change between time points 1 and 2 would be 3.25%.

Procedures for the trend analysis involved regression and hypothesis testing (involving two sample t-tests) methods where the explanatory variable was time and the directionality of the

trend was of interest. Methods to determine and understand both gradual (e.g. linear) and sudden (step) trends (change over time) with and without the effects of confounding variables (e.g. sex) were employed. The regression and hypothesis testing methods took account of the complex survey design, incorporating the sampling weights, clustering and stratification.

5.4.1 Results of trend analysis

The purpose of the trend analysis was to detect both gradual trends and step-changes over time, providing an up to date and robust assessment of the trend in salt intake in Scotland, using Scotland specific data collected from 2006 to 2014 and taking account of changes over time in laboratory analytical methods for sodium. Regression (gradual change) and hypothesis testing (step-changes) methods were performed. Figure 5.2 presents a scatterplot of the data used for the trend analysis, i.e. urinary sodium data from 2006-2014, and the estimated trend of estimated salt intake.³⁶

Using log-transformed estimates of salt intake, a linear regression model showed a downward linear trend in the geometric mean from 2006 (8.2g/day) to 2014 (7.1g/day). This 1.1g⁹ difference equates to a relative change in mean estimated salt intake of approximately 13%. This was a larger difference than found in England for 2005/06 to 2014 where there is a 0.9g difference that equates to a relative change in mean estimated salt intake of approximately 11%.

Investigation into step-changes showed there were no statistically significant step-changes between neighbouring groups of survey years³⁷ during the period of 2006 to 2014. Note that due to the overlap in collection periods and only four time points, it may be difficult to observe clear step-changes or the true quantification in the mean downward trend (i.e. the slope of the model).

A linear regression model with sex as a covariate was employed to ascertain whether there was a difference in the pattern and characteristics of men and women with respect to change over time, i.e. investigating an interaction between sex and time (year on year). There was no statistically significant difference in the linear trend between men and women. However, sex is statistically significant as a factor in the linear model to ascertain a downward linear trend.

The step-change analysis indicated there was a difference in this pattern between men and women. The main difference is that for women there is a statistically significant step-change observed between periods 2008/09-2009/10 (7.4g/day) and 2010/11-2012/13 (5.4g/day) whereas for all men a statistically significant step-change (although only marginally) is observed between periods 2010/11-2012/13 (9.4g/day) and 2014 (8.0g/day). No other statistically significant step-changes were observed between periods. It should be noted that the trend analysis involved four time points and hence three step-changes.

These differences in observed step-changes (between men and women) are also realised in the boxplots (presented in appendix C) and table D of geometric means. Figure 5.2 presents the scatterplot of the data (as in figure 5.1) with three lines for men, women and all (sex-combined adults) which connect the respective geometric means and therefore demonstrate the relative trends as the lines pass through the respective geometric mean.

Due to the low salt intake observed in the males 19 to 34 years age/sex group and the small number of participants in this group in 2014, the trend analysis involving a linear trend model and step-change analysis was performed both excluding this group and including this group. In both instances of either excluding or including the males aged 19 to 34 years from 2014, the linear model was statistically significant and suggested a downward linear trend. The step-change analysis when excluding the males aged 19 to 34 years, resulted in no statistically significant step-change between the 2010/11-2012/13 and 2014 period unlike when all the adult males aged 19 to 64 years were included. This difference is indicative of the lower salt intake observed and suggests that the subset of males aged 19 to 34 years pulls the downward trend further and hence a step-change is observed. For future studies, it is important to find ways of ensuring that adequate numbers of younger adults have the opportunity to be involved in 24-hour urine studies, in order to maintain the representativeness of the data, including consideration of the most appropriate participant selection method.

Figure 5.2: Estimated trend of estimated salt intake (g/day) in Scotland, by sex (2006-2014)

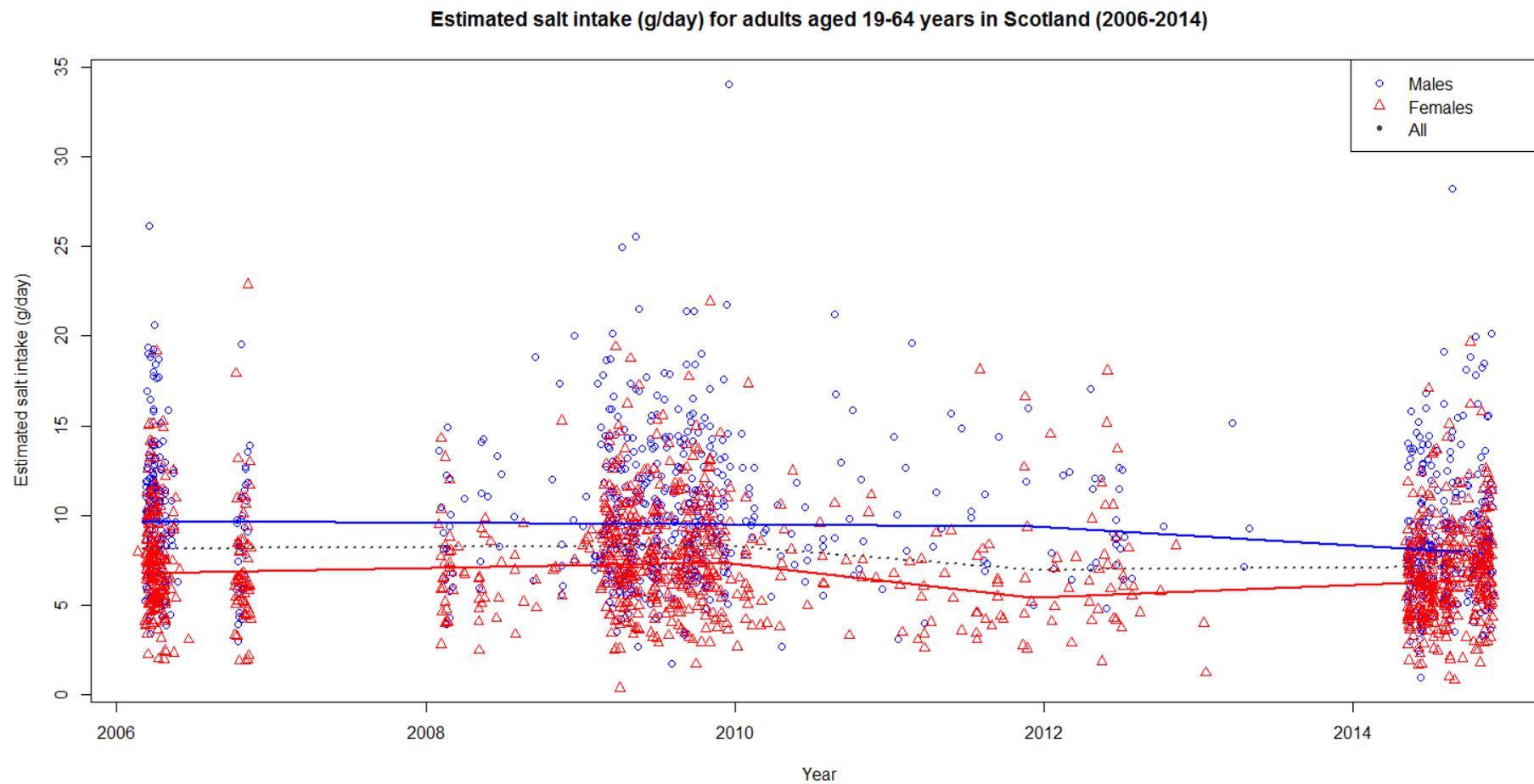


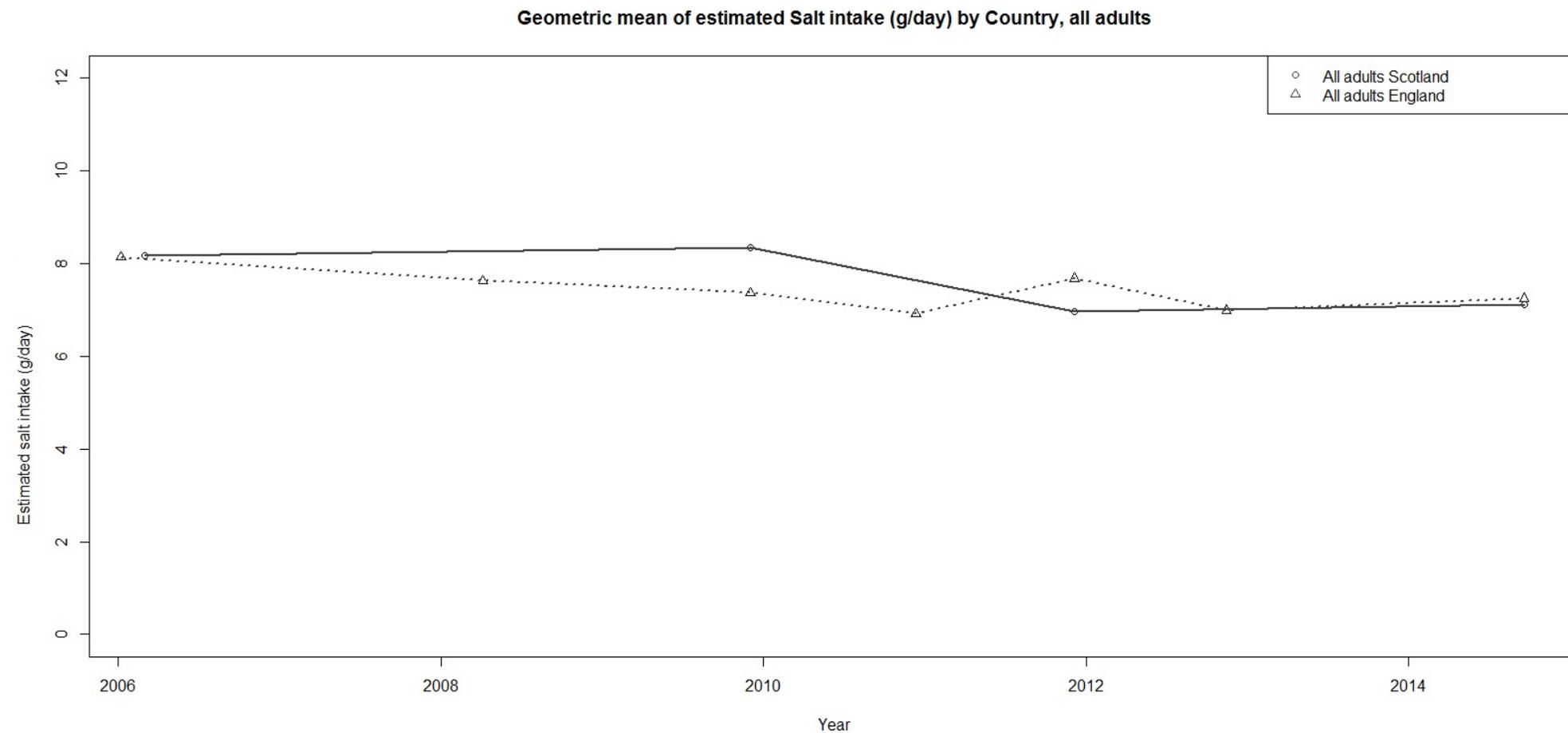
Table D: Number of participants, geometric means and SE of estimated salt intake (g/day) in Scotland between 2006 and 2014

Year	All participants			Men			Women		
	N	Geometric mean (g/day)	SE	N	Geometric mean (g/day)	SE	N	Geometric mean (g/day)	SE
2006	442	8.2	0.28	195	9.7	0.39	247	6.8	0.30
2008/09-2009/10	874	8.4	0.15	402	9.5	0.24	472	7.4	0.18
2010/11-2012/13	152	7.0	0.65	62	9.4	0.66	90	5.4	0.78
2014	663	7.1	0.21	294	8.0	0.24	369	6.4	0.24

At the same time as the Scotland 2014 sodium survey, a parallel survey was conducted in England. Although results from the 2005/06 survey in England and 2006 survey in Scotland indicated higher intakes in Scotland, results from the 2014 surveys indicate that current salt intakes in Scotland and England are similar (table 10 of respective reports and table 12 of this report).

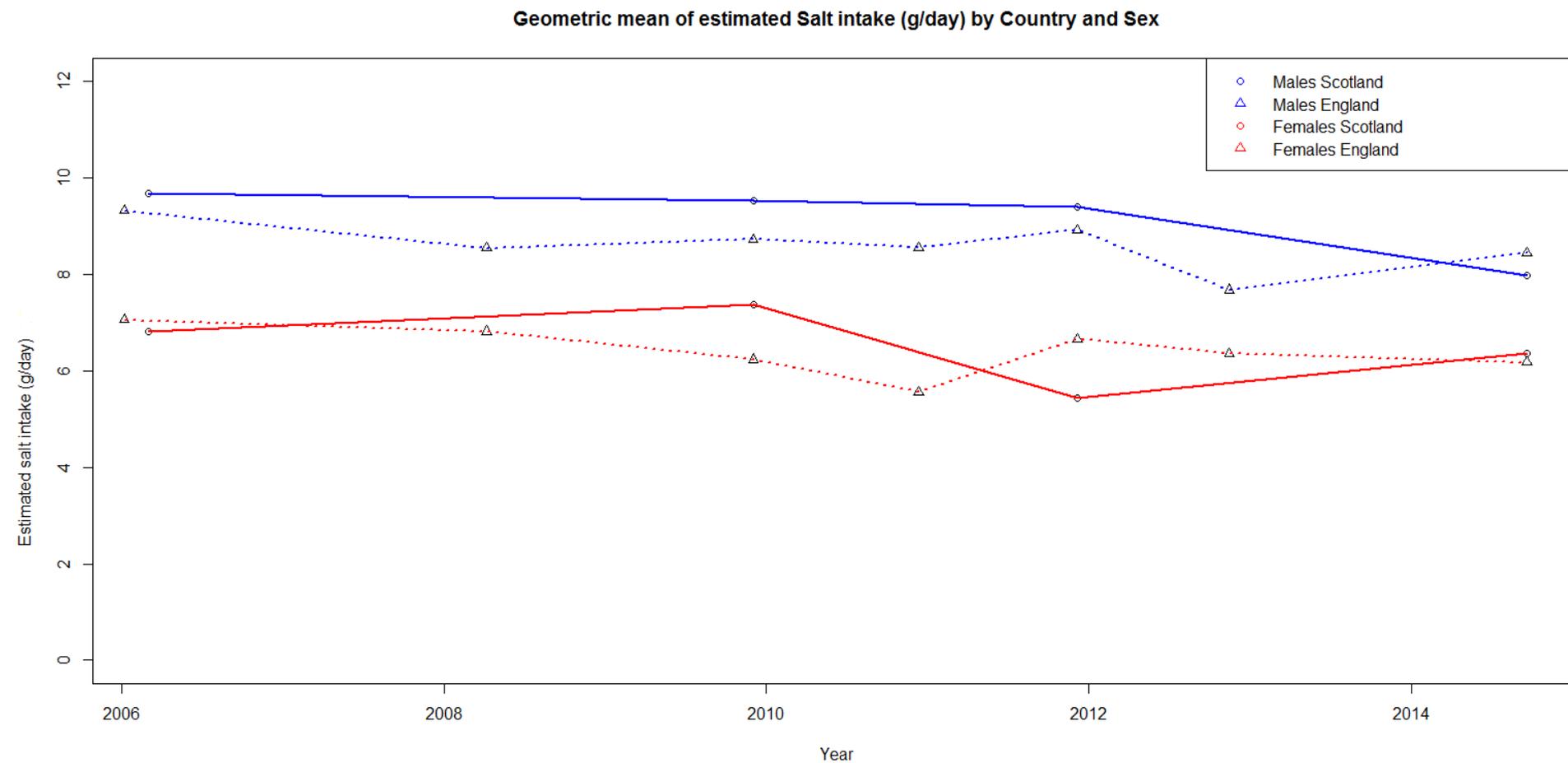
The results of the trend analysis by country and by sex of participants within country are presented in figure 5.3A and 5.3B. Results of separate trend and statistical analyses carried out in Scotland and England indicate a higher estimated reduction in salt intake in Scotland (13% from 2006 to 2014) compared to England (11% from 2005/06 to 2014).

Figure 5.3A: Estimated trend of estimated salt intake (g/day), by country (2005/06-2014)^a



^a It should be noted that the number of study time points used for the trend analysis differ between Scotland (4) and England (7).

Figure 5.3B: Estimated trend of estimated salt intake (g/day), by country and sex (2005/06-2014)^a



^a It should be noted that the number of study time points used for the trend analysis differ between Scotland (4) and England (7).

Appendix A Methodology: 2014 Scotland urinary sodium survey (adults aged 19 to 64 years)

A.1 Sample design

The aim was to obtain, over a five-month period (May to September 2014), 600 complete 24-hour urine collections representing the population of Scotland aged 19 to 64 years.

The Postcode Address File (PAF) was used to sample postcodes that were representative of the population. The sample was stratified by initially sorting the file by Government Office Region (GOR), then within each region the file was stratified into five equal bands based on the Index of Multiple Deprivation. Within each band the file was then sorted by population density. From this, 45 postcodes were selected.

Within the 45 postcode sectors a random sample of telephone numbers was drawn using Random Digit Dialling (RDD). RDD is a method where a representative sample of landline telephone numbers is generated at random from a frame of all possible telephone numbers.³⁸ The RDD sample covered all eligible telephone area codes located in the 45 selected postcode sectors. The database lists the first seven digits of all telephone numbers, including ex-directory numbers, which have been allocated to telephone companies for land lines (e.g. 01234 56XXXX). For each selected area code, the last four digits were randomly generated.

As well as including ex-directory numbers, RDD samples include disconnected numbers. As many non-working numbers as possible were removed before the sample was drawn.

A.2 Participant selection

The participants were recruited by NatCen's Telephone Unit (TU) interviewers. Within each household a maximum of two people aged 19 to 64 years were eligible to take part in the survey. Where there were more than two eligible adults in a household, two were randomly selected. Females who were pregnant or breastfeeding were not eligible to take part.

The sample in the last Scotland urinary sodium survey in 2009 was skewed towards women; 46% of the urine collections were from men and 54% from women. To increase the number of male participants in this current survey, men were given a higher chance of being selected and the results were weighted in order to make them representative of the adult population of Scotland.

A.3 Participant recruitment

Participants were recruited by NatCen's TU interviewers. Prior to starting work on the survey, TU interviewers attended a half-day training session which covered the background and purpose of the survey and their role in recruiting participants. Interviewers were also given detailed written project instructions covering the aims of the survey, methodology and fieldwork procedures.

The survey was referred to in the field as the "Diet and Health Study 2014" to minimise risk of participants changing their diets. Telephone interviewers (and nurses) were briefed not to mention salt but instead to say that we were interested in measuring nutrients such as sodium and potassium in the diet.

Telephone numbers were issued to the TU in seven batches. The TU interviewers attempted to make contact with the households of the generated telephone numbers and when successful followed a Computer Assisted Telephone Interviewing (CATI) script to introduce the survey and check the eligibility of household members. Within each household, up to two adults aged between 19 and 64 years were eligible to take part in the survey. If there were three or more eligible adults, two were selected at random within the CATI programme. The TU interviewer then sought agreement for a nurse to contact the selected participant(s) in order to arrange a home visit for collection of the 24-hour urine sample(s).³⁹

Each household that agreed to take part received a letter thanking them for their agreement to take part in the survey and informing them that the nurse would be in touch shortly to arrange a visit. They were also sent a leaflet outlining the survey in more detail. The details of those agreeing to be visited were passed on to the assigned nurse, who then provided further explanation about the survey and arranged a home visit appointment at a time convenient to the participant(s).

A.4 Nurse training

A combination of nurses who had previous experience of the 24-hour urine protocol and nurses who were new to the procedure were involved in the survey. Nurses who were not experienced in administering the 24-hour urine protocol attended a half-day face-to-face briefing. The briefings covered all elements of the survey including aims, background and methodology, fieldwork procedures and documentation, the Computer Assisted Personal Interview (CAPI) questionnaire and a practical demonstration of the equipment used to collect urine and the despatch procedures.

To ensure that all nurses followed the standard protocol, all fieldworkers, including those who did not attend a full briefing as they had previously worked on studies that included a 24-hour urine collection, such as the 2009 sodium study and the NDNS RP, were trained in the weighing and sub-sampling of the urine collection. All nurses were also given detailed written

project instructions covering the aims and objectives of the survey, fieldwork procedures and methodology of the survey and their performance in the use of the spring balance to measure accurately the mass of the filled urine container was assessed.

A.5 Nurse contact and first visit

The nurse made initial contact with the participant(s) via telephone, after which they sent a letter confirming details of the appointment date and time to the participant(s). The nurse then visited participating households at least twice. The purpose of the first nurse visit was to:

- encourage the participant(s) to take part and answer any questions they may have had
- check eligibility
- provide the participant(s) with detailed leaflets about PABA and the urine collection instructions (see appendix D)
- obtain written consent and deliver the equipment
- randomly allocate a date, via the CAPI programme, for when the participant(s) would carry out the 24-hour urine collection
- provide labelled Urine Collection Sheet
- book an appointment for the second visit (usually the day, or the day after, the 24-hour urine collection finished). The nurse completed an appointment card for the participant(s) to serve as a reminder of when the nurse would return to pick up the urine sample(s)

A.6 Urine collection protocol

After obtaining written consent (see appendix D), the nurse instructed participants in the 24-hour urine protocol. They were asked to collect all urine during a 24-hour period starting from the second morning urine pass of the 24-hour collection day, and ending with the first urine passed the following morning. The nurse used the CAPI programme to randomly allocate a day of collection for the participant(s). If the allocated date was unsuitable for the participant, CAPI would allocate an alternative start day. Participants often preferred to do their collection on a weekend day but in order to give an even representation across the week nurses would ask participants to collect on a Monday to Friday if a weekday was the day allocated by CAPI, explaining that their diet often differs between weekdays and weekends. Women were instructed to collect their urine on non-period days.

To make the 24-hour collection, participants were provided with the following equipment:

- five litre capacity screw cap (or jerry can) container to serve as the collection container for urine
- two litre capacity screw cap container for collections made away from the home. This was also used as an overflow container should the participant fill the five litre jerry can
- one litre plastic jug, kept inside a re-sealable plastic bag when not used

- funnel kept inside a re-sealable plastic bag when not used
- plastic carrier bags for transporting the equipment away from home
- an aide-memoire safety pin for the participant to pin the under- and outer-garments together during the period of the collection to remind that the specimen of urine about to be passed should be collected
- three PABA tablets to be taken to verify completeness of the 24-hour collection
- coloured stickers to distinguish equipment between two participants in the same household

Participants were instructed to pass urine into the one litre plastic jug, and then pour the sample into the five litre collection container using the funnel provided. Plastic bags were provided for participants to carry the equipment (including a smaller two litre collection container) if they were not at home for some of the collection period.

Participants were asked to take one PABA tablet on three occasions at evenly spaced intervals throughout the day of the collection. Participants were still eligible to take part if they were willing to carry out the 24-hour urine collection but did not want to (or could not) take PABA.

Before leaving the household the nurse recorded the participant details, the agreed start date of the 24-hour collection and whether the participant had consented to take PABA tablets on a Urine Collection Sheet (see appendix D). This sheet was then completed by the participant during the collection period. They were required to record the time they took the PABA tablets, the start and finish times of their urine collection, any missed urine passes, and any medication or supplements taken during the collection period.

A.7 Second nurse visit

Visit 2 took place on the day or the day after the 24-hour urine collection was completed. The nurse collected two sub-samples from the 24-hour urine sample and disposed of the remaining urine and equipment. To do this the nurse was supplied with the following equipment:

- Salter Brecknell ElectroSamson digital hand held scales for weighing the urine collection container (set on kg)
- two x 10ml Sarstedt Urine syringe and two extension tubes for urine monovettes for aliquoting urine
- disposable gloves, apron, disposable work mat for handling the urine
- jiffy bag and packaging material for despatching the samples
- participant-specific pre-printed labels for the filled monovettes

The container with the 24-hour collection was weighed twice by the nurse and the weight recorded on the despatch sheet and in the CAPI programme. The nurse then thoroughly mixed the urine by repeated inversion of the container before carrying out the sub-sampling

procedure, subsequent to which, the nurse discarded the remainder of the 24-hour collection and labelled the samples. The nurse also checked that the Urine Collection Sheet was complete (asking the participant for any missing information), paying particular notice to the start and end time, report of any missed collections or missed PABA tablets and any medications/supplements taken during the collection period. This information was entered into CAPI.

The nurse then packaged and posted the samples, Urine Collection Sheet, PABA blister pack and despatch paperwork to the laboratory at HNR.

A.8 Weighting

There were two stages to the weighting. The first step was to generate a set of weights to correct for unequal selection probabilities of individuals within households. The second stage was to make an adjustment for different levels of non-response.

A.8.1 Selection weights

A set of selection weights were generated to adjust the sample for selection of individuals within eligible households. Selection probabilities varied depending on the household type. Up to two adults aged 19 to 64 years were selected from each household, with male household members having a higher chance of being selected. Men in households with three or more eligible individuals were weighted by a factor of 1.56, whilst women within the households were given a weight of 1.00. A factor of 1.56 was chosen as it was estimated that this would increase young males in the responding sample by around 30% (as previous studies had shown that men had lower response rates). Two household members were then selected at random with probability proportional to this weight.

Selection weights are equal to the inverse of the selection probabilities:

- the selection weights for sample members in households with up to two eligible household members are equal to 1.00, since all eligible individuals were selected
- the selection probabilities for sample members in households with more than two eligible household members are equal to: $2 \times (\text{weighting factor} / \text{total weighting factor})$, where the weighting factor is 1.56 if the individual was male and 1.00 if the individual was female, and the total weighting factor is the sum of the weighting factors of all eligible household members. The selection weights are then equal to the inverse of this selection probability

A.8.2 Calibration of the selection weights

The selection weights were then adjusted to create a final set of weights for analysis. All individuals who provided a useable sample were given an analysis weight. The analysis weights were generated using calibration methods. The aim was to reduce bias resulting from sampling error and differential non-response by sex, age and GOR. An iterative procedure was used to adjust the selection weight until the distribution of the (weighted) sample matched that of the English population by age, sex and GOR. The adjustment keeps the values of the final weights as close as possible to those of the initial weights to ensure the properties of the initial weights are retained in the final calibrated weights. Population information about individuals aged 19 to 64 years and living in Scotland was taken from the 2014 mid-year population estimates.⁴⁰ The distributions of the population and weighted and unweighted samples are shown in table 11.

(Table 11)

Appendix B Urine analytical methods and quality control procedures: 2014 Scotland urinary sodium survey (adults aged 19 to 64 years)

B.1 Introduction

This appendix describes the methods used to measure urinary analytes and provides details of the quality control (QC) procedures for these assays for the Scotland urinary sodium survey 2014. The quality of the laboratory analyses is assured by rigorous instrument maintenance, staff training, adherence to standard operating procedures, membership of external quality assurance schemes and good laboratory practice. The QC and assessment practices used at HNR are all standard procedures for the type of assay used and HNR is ISO certified (BS EN ISO 9001:2008).

B.2 Analysis of urine samples

B.2.1 Sodium and potassium

Urinary sodium and potassium were measured using ion-specific electrodes (ISEs). The sodium and potassium methods on the Siemens Dimension® Xpand clinical chemistry system with the QuikLYTE® module are *in vitro* diagnostic tests intended for the quantitative measurement of sodium and potassium in urine, which use indirect sample sensing with the QuikLYTE® Integrated Multi-sensor Technology (IMT) to develop an electrical potential proportional to the activity of each specific ion in the sample. Each urine sample is diluted automatically and then transferred automatically to the sensor, where Na⁺ and K⁺ ions establish equilibrium with the electrode surface. A potential is generated proportional to the logarithm of the analyte activity in the sample. The electrical potential generated by a sample is compared with the electrical potential generated by a standard solution, and the concentration of the desired ions is calculated.

Sampling, dilution, reagent delivery, mixing, processing, calculation and printing of results are automatically performed by the Dimension® system. Samples are identified with bar codes; the instrument automatically uploads barcode and concentration information to a results

spreadsheet, thus eliminating transcription errors. The assay range is for sodium is 5-300mmol/L and for potassium 1-300mmol/L.

The Dimension method for sodium measurement shows good consistency but gives results which are lower than those given by other analytical methods in the National External Quality Assessment Scheme (NEQAS). Crossover studies have been performed in the HNR laboratories, comparing sodium concentrations in NDNS RP urines as measured using the Siemens Dimension with those obtained using the Roche Cobas C111 which gives results consistent with the consensus All Laboratory Trimmed Mean (ALTM) established by the UK NEQAS.⁴¹ The ALTM is the target concentration, the best indication available of the accurate concentration. These showed that urinary sodium measured using the Siemens Dimension at the time of this survey was approximately 5.2% lower than when measured on the Roche Cobas C111. Therefore, an method-specific factor of 1.052 was applicable to the Dimension results for urinary sodium. Application of this factor removes the negative bias shown in unchanged Siemens Dimension urine results relative to the ALTM for external quality assessment samples, (table B.2).

In this report, urinary sodium concentrations determined using the DimensionTM were multiplied by 1.052 to calculate the concentration of sodium in urine consistent with the ALTM. Other factors were applied to data from previous surveys as required to align them to the consensus ALTM (table C of chapter 5).

B.2.1.1 Quality controls (QC) for sodium and potassium

B.2.1.1.1 Internal QC

Internal commercially-prepared QC samples (Biorad Liquichek, Level 1 and Level 2) were run on the analyser to check for correct calibration and function before the samples were analysed, and included in every batch to determine between-assay precision. Once a bottle was opened, the remaining volume was aliquoted into smaller tubes and frozen at -20°C and then brought to room temperature and mixed thoroughly before use. The batch was accepted provided that the QC result obtained was within the manufacturer's specified range and also within the more stringent range determined within the laboratory.

Table B.1 Internal QC for sodium and potassium

	Internal QCs for sodium		Internal QCs for potassium	
	Level 1	Level 2	Level 1	Level 2
mean (mmol/L)	77.8	164	30.3	69.4
SD	0.90	0.95	0.51	0.77
% coefficient of variation	1.16	0.58	1.67	1.11
n	6	6	6	6

B.2.1.1.2 External quality assessment (QA)

HNR is a member of UK NEQAS for urinary sodium and potassium. This scheme sends samples to all hospital and many other analytical laboratories in the UK for analysis and compares results, to improve harmonisation of results between laboratories. NEQAS samples are urine or artificial matrices spiked to simulate the range of concentrations found in human urine.

Table B.2 summarises the results obtained over seven NEQAS cycles analysed alongside samples from the survey using the HNR Siemens Dimension assay relative to those obtained by other laboratories using the same method (“method mean”), and relative to the ALTM derived from the results of all participating laboratories by combining results obtained by all methods. The ALTM is the target concentration, the best indication available of the accurate concentration.

The first column of table B.2 shows that urinary sodium in the survey as measured on the DimensionTM analyser was lower than the ALTM. The second column demonstrates that when each individual sodium result was multiplied by the method-specific factor (1.052) as defined from the cross-calibration experiments carried out in our laboratories, the bias is resolved and the overall accuracy is improved. This factor has been applied to all urinary sodium concentrations measured for the 2014 assessment of dietary sodium survey and all previous urinary sodium concentrations measured using the Dimension at HNR and included in the trend analysis.

Table B.2 NEQAS results for urinary sodium and potassium July 2014 to Jan 2015

	sodium	sodium*1.052	potassium
% bias from ALTM	-5.57	-1.10	-3.16
SD of bias from ALTM	3.08	3.16	1.44
% bias from method mean	-2.29	2.87	3.04
SD of bias from method mean	4.08	4.09	2.03
n	21	21	21

B.2.2 Measurement of urinary para-aminobenzoic acid (PABA) by high performance liquid chromatography (HPLC)

PABA metabolites in urine are hydrolysed under alkaline conditions, the solution is then neutralised and the resultant PABA concentration determined by HPLC. The HPLC method is a reverse-phase method using an internal standard to compensate for volume losses during hydrolysis. The PABA HPLC method used at HNR is based upon that previously used at the MRC Dunn Nutrition Unit which in turn was based upon the method described by Jakobsen *et al.* (1997),²⁹ it was then modified at HNR to replace the acetonitrile in the mobile phase with methanol because of the unavailability of acetonitrile.

A recent methodological study (unpublished data) conducted at HNR showed that for the current analytical HPLC method, the appropriate cut-off for completeness in healthy adults is 70% (mean - 2SD) which incorporates both biological and methodological variation. The reference range for PABA excretion indicating a complete 24-hour urine collection, as assessed by this HPLC assay, was therefore established at HNR as 70 to 104% of the 240mg dose, using 50 adult volunteers (mean \pm 2 SD range). PABA excretion above this range could indicate either inadequate mixing of the urine before sampling or inaccurate recording of the volume, and therefore an incorrect 24-hour sodium excretion result, or ingestion of PABA in supplements which precludes assessment of completeness of urine collections by this method. Such urines were excluded from the dataset.

24-hour PABA excretion is calculated by multiplying concentration by 24-hour volume; this is then expressed as the percentage of the 240mg PABA dose recovered in the 24-hour collection ("PABA recovery") for comparison with the reference range above.

B.2.2.1 QC for PABA HPLC assay

B.2.2.1.1 Internal QC

A sample of urine containing PABA is analysed with each batch of samples in order to determine inter-assay variation. Assay results for each run are accepted if the QC results fall within limits defined within the laboratory, otherwise the batch is re-assayed.

Completeness of hydrolysis is monitored by including a sample containing PAHA (*para*-aminohippuric acid) with each batch. This is hydrolysed to PABA which is then quantitated by HPLC. 2mM PAHA theoretically yields 2mM PABA (i.e. 275mg/L). Quantitative hydrolysis of the PAHA indicates quantitative hydrolysis of urines prepared at the same time.

Table B.3 QC for PABA assay during the 2014 assessment of dietary sodium survey

	QC1	QC2	PAHA
Mean (mg/L)	76.0	34.2	273
SD (mg/L)	4.7	2.3	6.9
% coefficient of variation	6.2	6.6	2.5
n	113	107	115

B.2.2.1.2 External QA

There is no external QA scheme for PABA.

B.2.3 Creatinine

The creatinine method, performed on the Siemens Dimension® Xpand, employs a modification of the kinetic Jaffe reaction (Larsen). In the presence of a strong base such as sodium hydroxide, picrate reacts with creatinine to form a red chromophore. The rate at which absorbance at 510nm increases due to the formation of the chromophore is directly proportional to the creatinine concentration in the sample and is measured using a bichromatic (510, 600nm) rate technique. The reagents are formulated to avoid interference from any bilirubin present in the urine.



Creatinine in boric acid treated urine is stable for two to three days at room temperature and therefore posting of the urine aliquots to the laboratory was acceptable.

The assay range is 0 – 1768µmol/L. The limit of detection of the creatinine method is 4µmol/L; this represents the lowest concentration of creatinine that can be distinguished from zero (Siemens data).

Creatinine excretion is affected by muscle mass and recent meat consumption therefore varies considerably from person to person.

B.2.3.1 QC for Creatinine

B.2.3.1.1 Internal QC

The creatinine assay on the Siemens Dimension® Xpand is controlled with Lyphochek QC 1 and 2 produced by Bio-Rad Laboratories, included in every batch to determine between-batch precision. Once a bottle is opened, the remaining volume is aliquoted into smaller tubes and frozen at -20°C. QC material is brought to room temperature and mixed thoroughly before use.

The batch is accepted if the QC results fall within limits defined by the manufacturer and also within the more stringent range defined by the HNR laboratory.

Table B.4 Internal QC for creatinine during the 2014 assessment of dietary sodium survey

	Internal QCs for urinary creatinine	
	Level 1	Level 2
mean (mmol/L)	5.29	10.99
SD	0.04	0.22
% coefficient of variation	0.81	2
n	6	6

B.2.3.1.2 External QA

HNR subscribes to NEQAS for urinary creatinine; this scheme sends samples to all hospital and many other analytical laboratories in the UK for analysis and compares results, to improve harmonization of results between laboratories. NEQAS samples are urine or artificial matrices spiked to simulate the range of concentrations found in human urine.

Table B.5 summarises the results obtained using the HNR Siemens Dimension assay relative to those obtained by other laboratories using the Siemens Dimension kinetic Jaffe method, and relative to the ALTM derived from the results of all participating laboratories, over the period July 2014 to January 2015. The results are close to (i.e. within 1 standard deviation of) the ALTM target.

Table B.5 NEQAS results for urinary creatinine July 2014 – Jan 2015

	creatinine
% bias from ALTM	-3.48
SD of bias	4.76
n	21

Appendix C Methodology of trend analysis

C.1 Weightings used in the trend analysis

All available Scotland urinary sodium survey data (as detailed in table B, chapter 5) was included in the trend analysis. All surveys involved a complex survey design. Some surveys overlapped in collection periods and hence were combined. To combine the surveys and accounting for the complex survey design sample, sampling weights from each survey being combined were appropriately combined and rescaled using the 'combining weights' approach as set out by O'Muircheartaigh et al (2002).³³

C.2 Distribution of estimated salt intake

The distribution of estimated salt intake data included in the trend analysis is presented as boxplots by survey year and histograms (both original and logarithmic (natural log) scales) for men, women and sex-combined data. These plots incorporate the sampling weights used to reflect the distribution of the target population of the surveys.⁴²

The abbreviations in figures C.1 and C.2 are as follows:

- SSS 2006: Scotland 2006 sodium survey
- UKSS 2008, NDNS Y1&Y2, SSS 2009: UK 2008 sodium survey, NDNS Year 1 (2008/09) and NDNS Year 2 (2009/10), Scotland 2009 sodium survey
- NDNS Y3 & Y4 & Y5: NDNS Year 3 (2010/11), NDNS Year 4 (2011/12) and NDNS Year 5 (2012/13)
- SSS 2014: Scotland 2014 sodium survey

Figure C.1A: Boxplots of estimated salt intake of adults aged 19 to 64 years in Scotland by survey (2006-2014) - showing median, first and third quartiles, and very high or very low observations⁴²

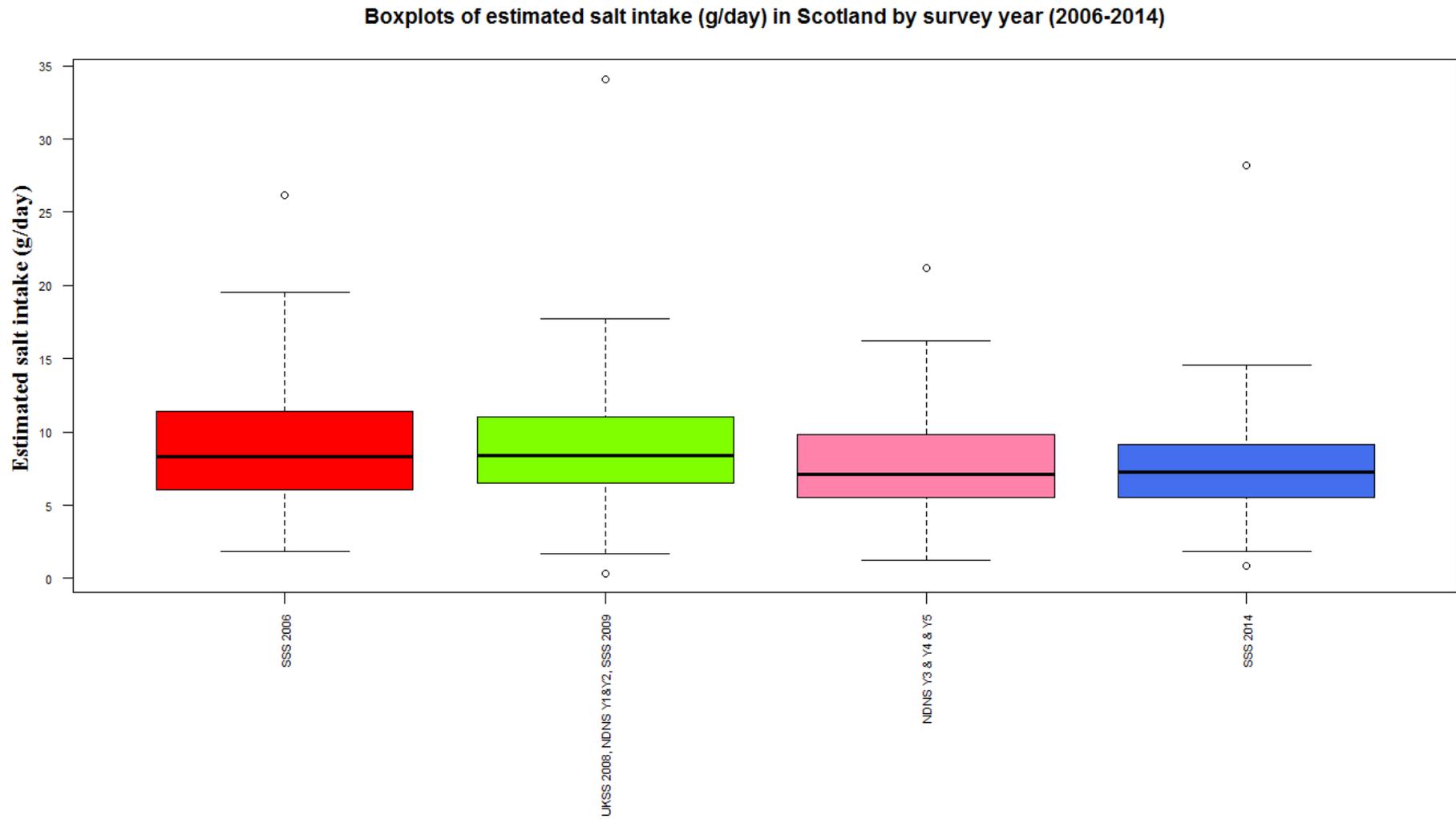


Figure C.1B: Boxplots of estimated salt intake (in natural log scale) of adults aged 19 to 64 years in Scotland by survey (2006-2014) - showing median, first and third quartiles, and very high or very low observations⁴²

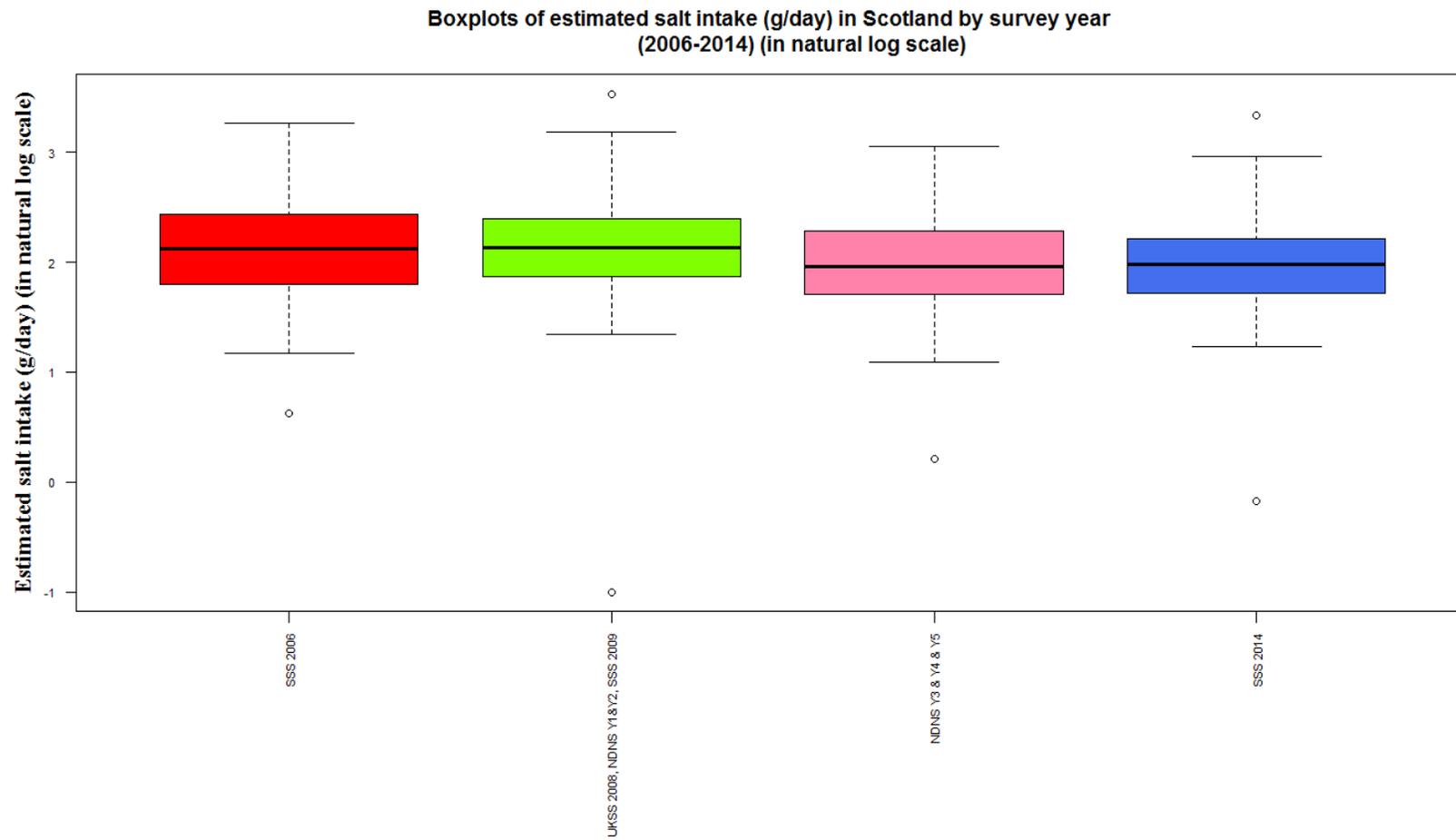


Figure C.2A: Boxplots of estimated salt intake of adults aged 19 to 64 years in Scotland by sex and survey year (2006-2014) - showing median, first and third quartiles, and very high or very low observations⁴²

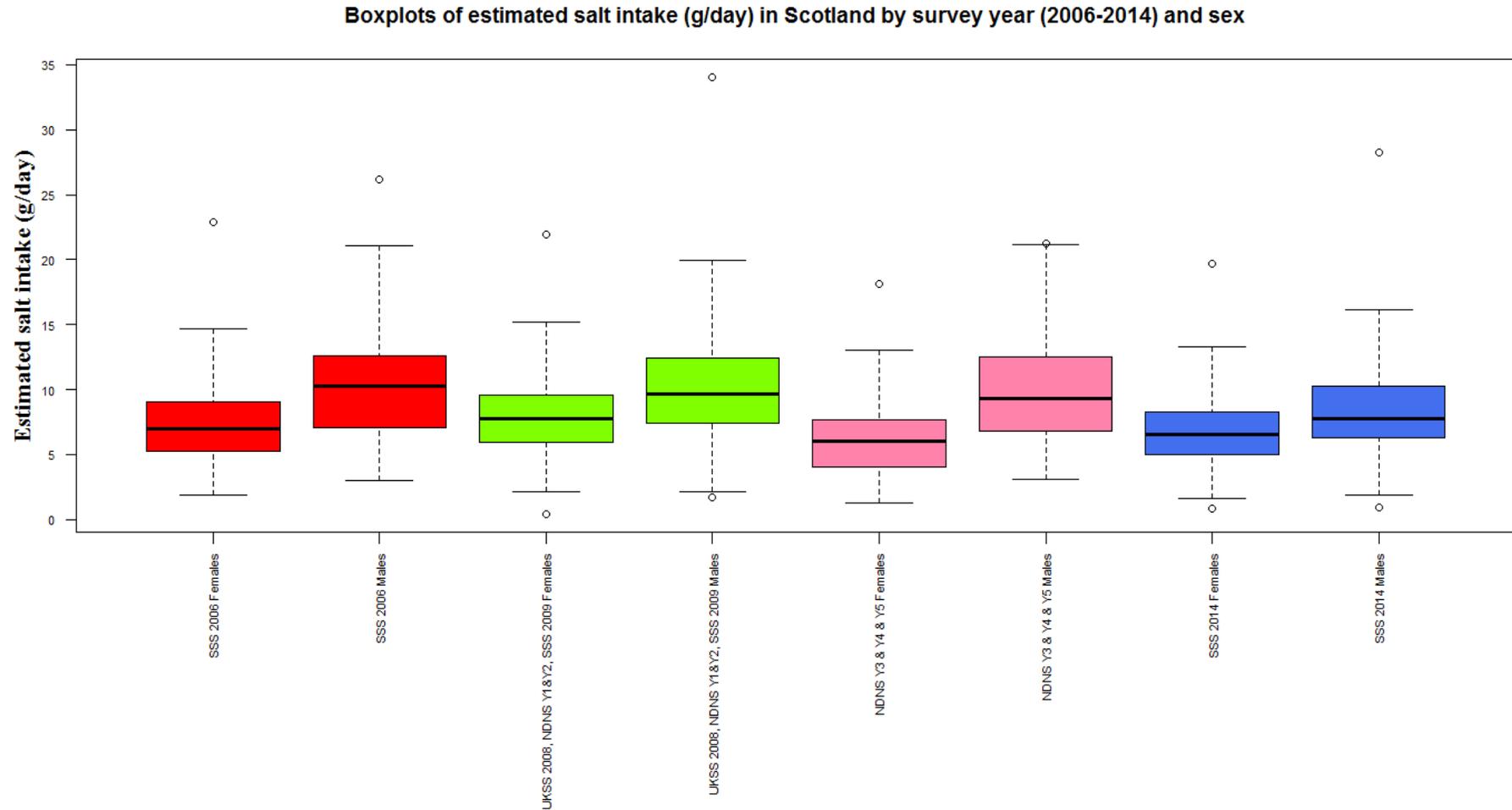
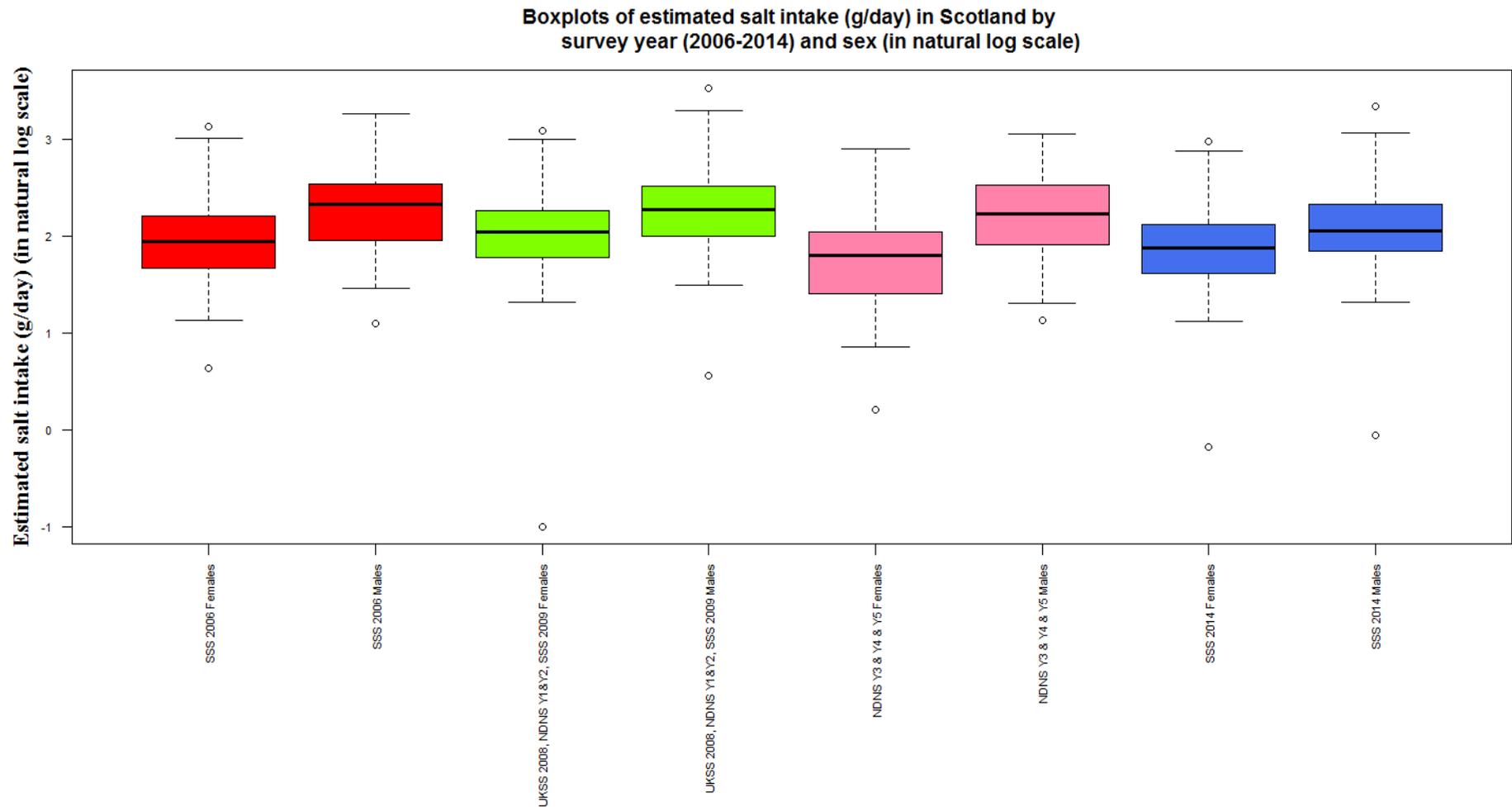


Figure C.2B: Boxplots of estimated salt intake (in natural log scale) of adults aged 19 to 64 years in Scotland by sex and survey year (2006-2014) - showing median, first and third quartiles, and very high or very low observations⁴²



The asymmetrical histograms above demonstrate that the data are not normally distributed. They are plotted below as log-transformed data which produce a more symmetrical normal distribution.

Figure C.3 Histograms of estimated salt intake of adults aged 19 to 64 years in Scotland by sex (2014)

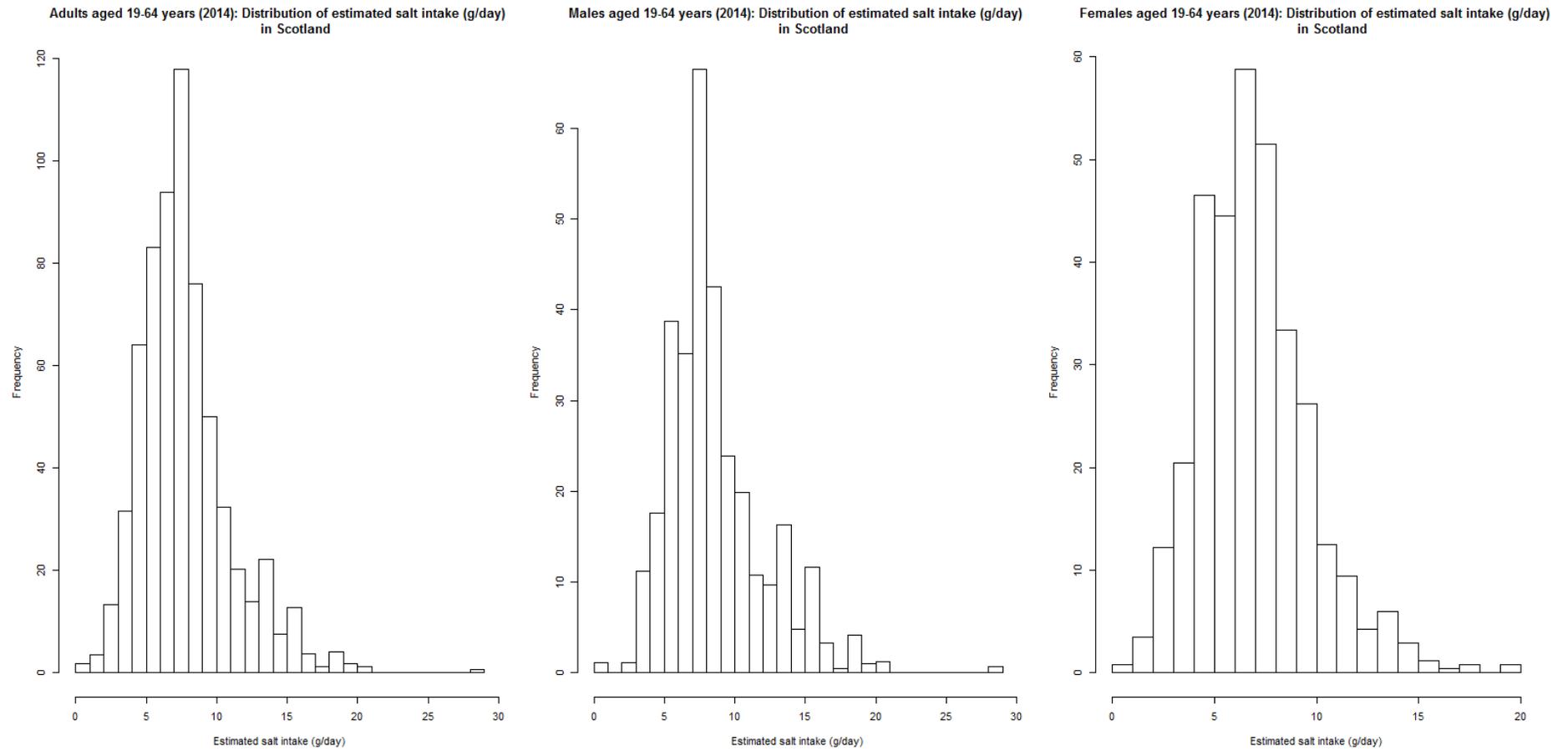
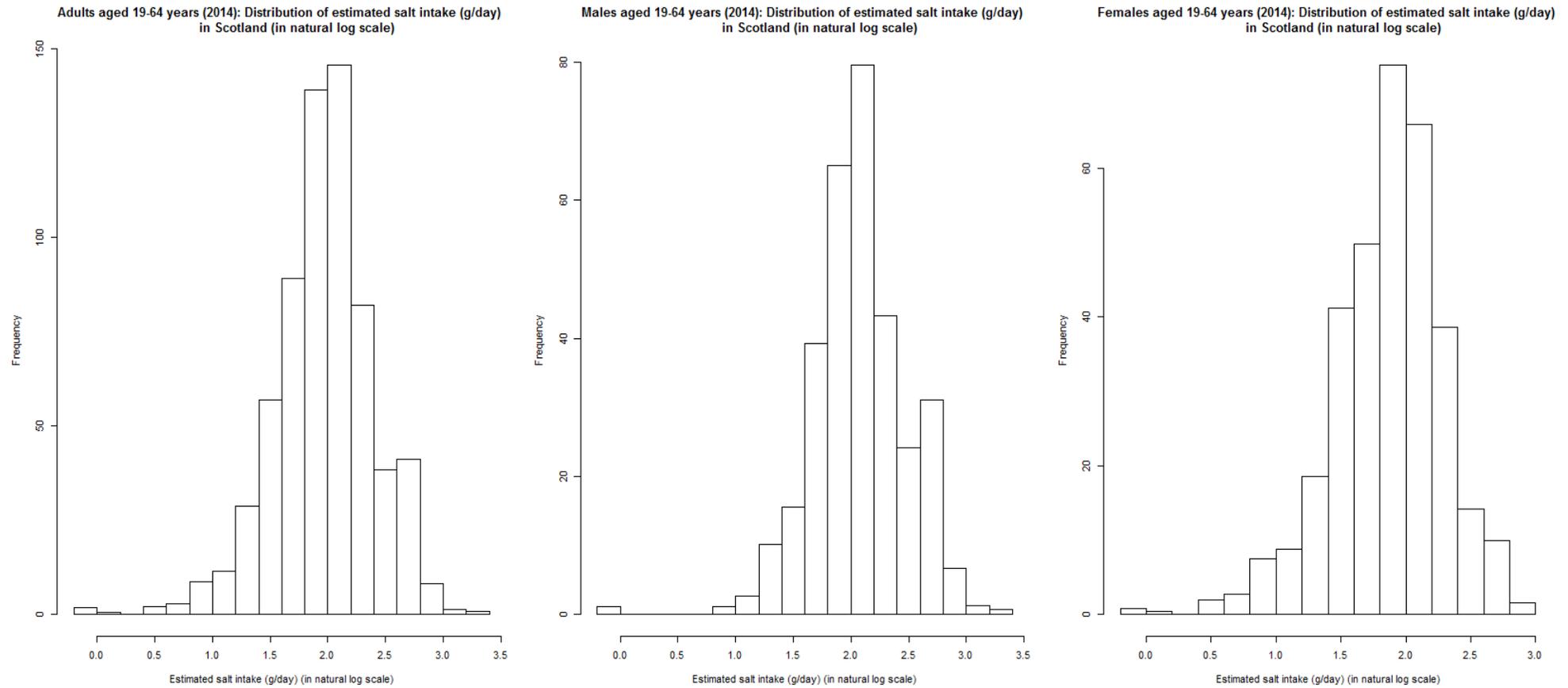


Figure C.4: Histograms of estimated salt intake (in natural log scale) of adults aged 19 to 64 years in Scotland by sex (2014)



Appendix D Field documents

See separate document

- ¹ Bibbins-Domingo, K., Chertow, G. M. , Coxson, P.G., Moran, A. , Lightwood, J.M., Pletcher, M. J., and Goldman, L. (2010) *Projected Effect of Dietary Salt Reductions on Future Cardiovascular Disease*. The New England Journal of Medicine. 362:590-599.
- ² Scientific Advisory Committee on Nutrition (2003). Salt and Health. The Stationery Office. http://www.sacn.gov.uk/pdfs/sacn_salt_final.pdf. (The recommendation is for no more than 6g of salt per day.) (accessed 02/03/16).
- ³ The recommendation is no more than 5g/day of salt intake for females and no more than 7g/ day of salt intake for males.
- ⁴ <http://www.sciencedirect.com/science/article/pii/S0140673687901279> (accessed 08/03/16).
- ⁵ <http://webarchive.nationalarchives.gov.uk/20080910120337/food.gov.uk/healthiereating/salt/> (accessed 08/03/16).
- ⁶ <http://www.foodstandards.gov.scot/2017-salt-targets> (accessed 08/03/16).
- ⁷ Joint Health Surveys Unit (NatCen and UCL). A survey of 24-hour and spot urinary sodium and potassium excretion in a representative sample of the Scottish population. <http://www.foodstandards.gov.scot/assessment-dietary-sodium-levels-general-population-scotland>. Originally published March 2007, revised May 2011, (accessed 02/03/16).
- ⁸ A survey of 24-hour urinary sodium excretion in a representative sample of the Scottish population as a measure of salt intake. <http://www.foodstandards.gov.scot/survey-24-hour-urinary-sodium-excretion-representative-sample-scottish-population-measure-salt>. Published April 2011, (accessed 02/03/16).
- ⁹ The difference between the geometric means has been calculated using unrounded data rather than the rounded figures in Table 10.
- ¹⁰ The SACN recommendation that population salt intake should not exceed 6g/day applies to adults and children from 11 years and lower recommendations are set for children aged 4 to 6 years (no more than 3g/day) and 7 to 10 years (no more than 5g/day).
- ¹¹ Scottish Government. Revised Dietary Goals for Scotland. Edinburgh 2013. Available: <http://www.gov.scot/Topics/Health/Healthy-Living/Food-Health/DietaryGoalsScot> (accessed 02/03/16).
- ¹² An assessment of dietary sodium levels among adults (aged 19-64) in the general population in Wales based on analysis of dietary sodium in 24 hour urine samples. Feb 2007. <http://webarchive.nationalarchives.gov.uk/20101211052406/http://www.food.gov.uk/multimedia/pdfs/walessodiumreport.pdf> (accessed 02/03/16).
- ¹³ An assessment of dietary sodium levels among adults (aged 19-64) in the UK general population in 2008, based on analysis of dietary sodium in 24 hour urine samples, June 2008; <http://tna.europarchive.org/20110116113217/http://www.food.gov.uk/multimedia/pdfs/08sodiumreport.pdf> (accessed 02/03/16).
- ¹⁴ National Diet and Nutrition Survey - Assessment of dietary sodium in adults (aged 19 to 64 years) in England, 2011 report. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/127916/Sodium-Survey-England-2011_Text-to-DH_FINAL1.pdf.pdf (accessed 02/03/16).
- ¹⁵ British Heart Foundation (2015) BHF Headline Statistics. British Hearth Foundation. <http://www.bhf.org.uk/research/statistics.aspx> (accessed 02/03/16).

- ¹⁶ Department of Health (1994). Nutritional Aspects of Cardiovascular Disease. Report on Health and Social Subjects 46. London: The Stationery Office.
- ¹⁷ Scottish Executive's "Eating for Health: Diet Action Plan for Scotland <http://www.gov.scot/Resource/0040/00400745.pdf> (accessed 02/03/16).
- ¹⁸ Scottish Government and the Food Standards Agency in Scotland 2014. Supporting Healthy Choices: A Framework for Voluntary Action. Available: <http://www.gov.scot/Publications/2014/06/8253/downloads> (accessed 02/03/16).
- ¹⁹ <http://www.scotland.gov.uk/Topics/Health/Healthy-Living/Food-Health/Food-Programmes> (accessed 02/03/16).
- ²⁰ <http://tna.europarchive.org/20090810121540/http://salt.gov.uk/index.html> (accessed 02/03/16).
- ²¹ <http://www.eatbetterfeelbetter.co.uk/> (accessed 02/03/16).
- ²² In the NDNS RP there was a general sample population boost in Scotland between 2008/09 and 2011/12 (Years 1 to 4).
- ²³ <http://www.foodstandards.gov.scot/national-diet-and-nutrition-survey-rolling-programme-results-years-1-4-combined-scotland-200809> (accessed 02/03/16).
- ²⁴ A survey was also carried out in Northern Ireland in 2015; results will be published later in 2016.
- ²⁵ On the 1st April 2015, FSS took on all of the functions previously carried out in Scotland by the Food Standards Agency.
- ²⁶ The sample was drawn from the 'small users' sub-file of the Postcode Address File (PAF), a computer list, prepared by the Post Office, of all the addresses (delivery points) which receive fewer than 25 articles of mail a day.
- ²⁷ Households without a landline were excluded.
- ²⁸ Bingham S and Cummings J H. The use of 4-aminobenzoic acid as a marker to validate the completeness of 24h urine collections in man. *Clin Sci (Lond)* 1983; 64(6):629-35.
- ²⁹ Jakobsen J, Ovesen L, Fagt S, et al. Para-aminobenzoic acid used as a marker for completeness of 24-hour urine: Assessment of control limits for a specific HPLC method. *Eur J Clin Nutr* 1997; 5: 514.
- ³⁰ 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.
- ³¹ NHS choices website: Salt: the facts <http://www.nhs.uk/Livewell/Goodfood/Pages/salt.aspx> (accessed 02/03/16).
- ³² For reporting purposes, arithmetic means have been provided. Due to the skewed nature of the data, geometric means have been calculated (by transforming the data on a natural logarithmic scale) and used for statistical analyses to evaluate relative changes in the data (e.g. between years or groups) and minimize bias from the skewed data.
- ³³ O'Muircheartaigh, Colm and Pedlow, Steven (2002). Combining samples vs. cumulating cases: a comparison of two weighting strategies in NLSY97. *ASA Proceedings of the Joint Statistical Meetings*, pp. 2557-2562. American Statistical Association (Alexandria, VA).
- ³⁴ NDNS 2000/2001 are included in the Table 5.1 for completeness only as they were included in the most recent published Sodium survey reports (2011).

³⁵ The geometric mean is calculated from log-transformed data whereas the arithmetic mean is calculated from non-transformed data.

³⁶ As noted earlier data from 2000/2001 (figure 5.1) were not included in the analysis because these data would not set a suitable baseline for the target trend following the salt reduction policy introduced in 2003. There is also the risk that these data would unduly influence the overall trend because there is no data available between 2001 and 2006.

³⁷ Between neighbouring groups of survey years i.e.: 2006 'v' 2008/10, 2008/10 'v' 2010/13, 2010/13 'v' 2014.

³⁸ As the sampling frame excluded households without landlines, there was an element of non-coverage bias (as those without a landline had zero chance of being included).

³⁹ At this point the participant was only agreeing to be contacted by a nurse. Formal consent to take part in the study was obtained by the nurse.

⁴⁰ <http://www.ons.gov.uk/ons/rel/pop-estimate/population-estimates-for-uk--england-and-wales--scotland-and-northern-ireland/mid-2014/index.html> (accessed 02/03/16).

⁴¹ The consensus is the All Laboratory Trimmed Mean (ALTM).

⁴² Each box in the boxplots of figures C.1-C.2 represents the first quartile (bottom of the box; 25th percentile), the median (middle of the box; 50th percentile) and the third quartile (top of the box; 75th percentile). The whiskers (bottom and top) help the identification of very high or very low observations. These are demarcated by the maximum and minimum observations or by 1.5 interquartile ranges beyond the end of the box, whichever are closer to the box. The maximum and minimum are plotted as outliers if they are beyond the ends of the whiskers, but other outlying points are not plotted. The histograms in figures C.3-C.4 illustrate the skewed distribution of salt intake in its original (or raw) form, and subsequent less skewed distributional form after a natural log-transformation of the data.