Assessment of dietary sodium in adults aged 19 to 64 years: England (2006), Scotland (2006 & 2009), Wales (2007) and UK (2008)

User Guide

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Contents

1 Background

The Scientific Advisory Committee on Nutrition (SACN)[1] recommend a target reduction in the average salt intake of the population to no more than 6g 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. Following publication of the SACN report in 2003, the government began a programme of reformulation work with the food industry aimed at reducing the salt content of processed food products. Voluntary salt reduction targets were first set in 2006, and subsequently in 2009, 2011 and 2014, for a range of food categories that contribute the most to the population's salt intakes.

Dietary salt intake can be assessed by measuring sodium excretion in urine. A 24-hour urine collection method was used as it is regarded as the gold-standard method of assessing salt intake in population surveys[2] and was consistent with previous surveys. Since the level of sodium in urine fluctuates according to what was eaten at the last meal and how much fluid an individual has drunk, and because salt is the predominant source of sodium in the UK diet, a urine collection over 24 hours is accepted as being the most reliable method for assessing salt intake in the population. Results from an incomplete 24-hour urine collection are misleading because they do not reflect 24-hour intake. To be usable in the final analysis the 24-hour collection had to be complete, or within the range regarded as "adjustable" which can be assessed by analysis of para-aminobenzoic acid (PABA) excretion.

Eleven urinary sodium surveys of adults aged 19 to 64 years have been conducted (as part of NDNS or as stand-alone surveys) between 2000 and 2015, some covering the UK as a whole and some in a single devolved country, these are as follows:

- NDNS adults aged 19 to 64 years; 2000/01[3]
- England 2006 sodium survey of adults aged 19 to 64 years[4] (included in this dataset)
- Scotland 2006 sodium survey of adults aged 19 to 64 years[5] (included in this dataset)
- Wales 2007 sodium survey of adults aged 19 to 64 years[6] (included in this dataset)
- UK 2008 sodium survey of adults aged 19 to 64 years[7] (included in this dataset)
- Scotland 2009 sodium survey of adults aged 19 to 64 years[8] (included in this dataset)
- NDNS Rolling Programme; 2008-2013[9]

- England 2011 sodium survey of adults aged 19 to 64 years[10]
- England 2014 sodium survey of adults aged 19 to 64 years[11]
- Scotland 2014 sodium survey of adults aged 19 to 64 years[12]
- Northern Ireland 2015 sodium survey of adults aged 19 to 64 years[13]

2 National Diet and Nutrition Rolling Programme (NDNS RP) sodium surveys

The NDNS programme began in 1992 as a series of cross-sectional surveys, each covering a different age group. Prior to 2008 the NDNS covered one age group at a particular time-point. Since 2008, the NDNS has been a RP covering adults and children aged 1.5 years and over. Data collected during the five sodium surveys conducted between 2006 and 2009 are contained in one combined data file and described in this user guide. The NDNS RP collection includes four separate survey assessments of dietary sodium in adults, which are archived in the main datasets for Years 1-4 and Years 5-6 and described in the associated user guide.

All surveys had the following common aims:

- to assess urinary sodium excretion in adults aged 19 to 64 years by collecting and analysing 24-hour urine samples for a representative sample of the population
- to estimate dietary salt intakes (g/day) from urinary sodium excretion
- provide data to establish the progress towards meeting the FSA target to reduce sodium intakes reduce average salt intakes across the population from 9.5g to 6g per day by 2010, with an interim target of a 10% reduction in 2005/06

2.1 England 2006 sodium study

Urine samples were collected over 10 months (October 2005 to July 2006). For adults aged 19 to 64 years, 445[14] provided a 24-hour urine collection that was deemed complete, including 82 collections where the sodium content was considered “adjustable” for marginal incompleteness (see section 5.1 for more details).

2.2 Scotland 2006 sodium study

Urine samples were collected over 9 months (March to November 2006). For adults aged 19 to 64 years, 442 of these 24-hour collections were deemed complete including 75 collections where the sodium content was considered “adjustable” for marginal incompleteness (see section 5.1 for more details).

2.3 Wales 2007 sodium study

Urine samples were collected over 7 months (May to November 2006). For adults aged 19 to 64 years, 407 of these 24-hour collections were deemed complete including 99 collections where the sodium content was considered “adjustable” for marginal incompleteness (see section 5.1 for more details).

2.4 UK 2008 sodium study

Urine samples were collected over 5 months (January to May 2008). For adults aged 19 to 64 years, 692 of these 24-hour collections were deemed complete including 99 collections where the sodium content was considered “adjustable” for marginal incompleteness (see section 5.1 for more details).

2.5 Scotland 2009 sodium study

Urine samples were collected over 14 months (January 2009 to February 2010). For adults aged 19 to 64 years, 702 of these 24-hour collections were deemed complete including 150 collections where the sodium content was considered “adjustable” for marginal incompleteness (see section 5.1 for more details).

3 Survey Design and Weighting

3.1 England 2006 study

Respondents were selected from those who had taken part in the Health Survey for England (HSE) 2005. Within each household, no more than two adults, aged between 19-64 years, were eligible to take part in the study. Data collection took place between October 2005 and July 2006, with the majority of fieldwork being completed by March 2006.

In the majority of households, there were only one or two adults within the age range of 19-64 years and therefore eligible for the urine study. However, in a small minority of households there were more than two eligible adults, and in these households two individuals were selected to take part in the study. Selection weighting has been applied to correct for the probability of selection for the adults in these larger households. In addition, the achieved sample of individuals who provided 24-hour urine samples slightly under-represented men and younger adults. The profile of the sample has therefore also been weighted to match the 2004 mid-year population estimates for adults aged 19-64 years in England.

3.2 Scotland 2006 study

Participants were recruited from two sources:

- The Scottish Health Survey (SHeS) 2003
- Random digit dialling (RDD) as a follow up to SHeS 2003

Within each household, no more than two adults, aged 19-64 years, were eligible to take part in the study. Data collection took place between March and November 2006.

The Primary Sampling Units (PSUs) selected for this study were clusters of those used in SHeS. SHeS sampling points were grouped to provide some clustering and then 34 pairs of points were selected. A set of selection weights were generated to adjust for over-sampling in some areas and so that the results were nationally representative. In addition the households in the sample re-contacted from SHeS were also given the SHeS household non-response weight. Selecting two persons per household means people living in households with three or more eligible people are under-represented in the sample. A person selection weight is required; this is the inverse of the person selection probability and is equal to 1 where there are fewer than 3 persons per household. Where there are 3 or more eligible persons the weight is equal

to the number of eligible adults in the household divided by 2. Calibration weighting was applied to the weights already described, to create a new set of weights that adjusted the profile of the achieved sample to match the population of persons aged 19-64 years in terms of age and sex. The population figures were taken from the 2005 mid-year population estimates generated by General Register Office for Scotland (GROS).

3.3 Wales 2007 study

A random sample of 30 postcode sectors was selected initially, and within these a random sample of telephone numbers was drawn using RDD. A RDD sample of telephone numbers from within the 30 postcode sectors was selected. Within each household, no more than two adults, aged between 19-64 years, were eligible to take part in the study, and if there were three or more eligible adults two were selected at random. Data collection took place between May and November 2006.

In the majority of households, there were only one or two adults within the age range of 19-64 years and therefore eligible for the urine study. However, in a small minority of households there were more than two eligible adults, and in these households two individuals were selected to take part in the study. Selection weighting has been applied to correct for the probability of selection for the adults in these larger households.

As a final correction the individual selection weights were adjusted using rim weighting to adjust the age and sex distribution of the sample to match that of the population. The population figures were taken from the ONS 2005 mid-year population estimates for individuals living in Wales aged 19-64 years.

3.4 UK 2008 study

A random sample of 45 postcode sectors was selected initially, and within these a random sample of telephone numbers was drawn using RDD. Within each household, up to two adults, aged between 19-64 years, were eligible to take part in the study, and if there were three or more eligible adults two were selected at random. Data collection took place between January and May 2008.

In 29 of the 45 selected areas the full reserve sample was issued to interviewers. In the remaining 16 only a proportion of the reserve numbers were used, individuals in these areas had a lower chance of being included in the sample and an adjustment was made accordingly. Households in areas where the full sample was issued were given a weight of 0.82 (i.e. the number

issued in partial areas / the full main + reserve sample; 230/280). Households in the remaining areas had a weight of 1. Selection weighting has been applied to correct for the probability of selection for the adults in larger households.

As a final correction the individual selection weights were adjusted using rim weighting to make the sample distribution match the UK population by age, sex and country. The population figures were taken from the ONS 2006 mid-year household population estimates for individuals aged 19-64 years living in the UK.

3.5 Scotland 2009 study

The sample of respondents SHeS 2009 household sample. Up to two respondents aged 19-64 years in each household that completed a main SHeS interview in 2009 were invited to participate in the 24-hour urinary sodium study follow-up nurse visit. Where there were more than two eligible adults in a household, two individuals were selected at random. Data collection took place between January 2009 and February 2010.

The weighting process involved using the calibrated household weight already calculated for the main sample. Corrections were made for whether the household was selected to be in the sodium sample. Additional selection weights were generated for whether the respondent was selected for the sodium study (this was equal to one if there were only one or two eligible adults in the household, and for larger households it was the number of eligible adults divided by two). These were then combined with the weights with the adult non-response weight (described in the main report). Non-response weights were generated for whether a responding adult gave a usable urine sample; and then the combined weight was post-stratified to the population estimates and scaled to give the final weight. The population figures were taken from the 2008 mid-year household population estimates generated by General Register Office for Scotland (GROS).

4 24-hour Urine Collection Protocol

After providing written consent, participants were asked to collect all urine they passed during a 24-hour period starting from the second morning urine passed the 24-hour collection day, and ending with the first urine passed the following morning. Participants were also asked to take three para-amino benzoic acid (PABA) tablets at evenly spaced intervals throughout the day of the collection. Analysis of PABA excretion provided a measure of the completeness of the 24-hour urine sample. Participants were only included in the 5 sodium surveys represented in this dataset if they agreed to take PABA. In later sodium surveys participants were still eligible to take part if they did not want or were unable to take PABA but were willing to carry out the 24-hour urine collection (see user guide for the combined 2011-2015 sodium survey dataset[15]).

After the collection period, the nurse/fieldworker[16] weighed the urine that had been collected, took two sub-samples and disposed of the remaining urine and equipment. Measurement of urinary sodium was carried out using an ion-selective electrode on the Roche/Hitachi systems at the Doctors Laboratory, London for the England and Scotland 2006 and Wales 2007 surveys, by flame photometry on an Instrumentation Laboratory (IL) 943 Flame Photometer (Milan, Italy) using a caesium internal standard at MRC Human Nutrition Research, Cambridge for samples collected for the UK 2008 survey and using an ion selective electrode on the Siemens Dimension® Xpand clinical chemistry system with the QuikLYTE® module at MRC Human Nutrition Research, Cambridge for samples collected for the Scotland 2009 survey. The 24-hour excretion was determined by multiplying urinary concentration by 24-hour volume (determined by weighing the collection). See below for notes regarding adjustment of urinary sodium excretion to allow for marginally incomplete collections and correction of sodium concentrations to compensate for slight instrumental bias, where these were necessary.

Urinary potassium and creatinine were measured simultaneously with sodium.

The data were validated as representing intake over 24 hours by checking completeness of the urine collections by the para-aminobenzoic acid (PABA) method. Collections containing ≥85% of the PABA dose (measured by colorimetry) were deemed complete. Those containing 70%-84%[17] of the PABA dose were considered “marginally incomplete” and the content of sodium adjusted for this incompleteness according to Johansson et al.[18] using the following equation:

> Adjusted Na content = measured Na content + 0.82*(93-%PABA recovery)

Marginally incomplete urine collections have a ‘urine eligibility code’ status of “complete”, but can be identified where PABA is in the range 70-84%.[17]

Potassium and creatinine excretion data in these marginally incomplete urine collections have not been adjusted thus: PABA recovery data are included in the archive to allow users to perform such adjustment[18] if required.

Sodium excretion adjustment for those participants who provided a "marginally incomplete" 24-hour urine collection					
	England 2006	**Scotland 2006**	**Wales 2007**	**UK 2008**	**Scotland 2009**
Sodium excretion adjusted when colorimetric PABA recovery was between 70-84%[17]	Yes	Yes	Yes	Yes	Yes
Sodium excretion adjusted when HPLC PABA recovery was between 75-77%	No HPLC PABA	Yes	No	Yes	No[1]

[1] Based on data in the combined dataset accompanying this User Guide.

5 Correction of instrumental bias in urinary sodium excretion

Laboratory methods for the measurement of sodium have evolved over time and different surveys have consequently used different methods (for more information see table B of the 2014 England sodium survey report). 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 (for more information see table B of the 2014 England sodium survey report[11]).

- Urinary sodium for the UK 2008 survey was measured using flame photometry on an Instrumentation Laboratory (IL) 943 Flame Photometer (Milan, Italy) using a caesium internal standard at MRC Human Nutrition Research, Cambridge. This was shown to have a small positive bias for the UK 2008 samples relative to instruments providing accurate urinary sodium measurements as assessed by UK NEQAS; within acceptable limits for diagnostic purposes but not for assessment of population sodium intake and investigation of trends in this over time.
- Urinary sodium for the Scotland 2009 survey was measured using the Siemens Dimension Xpand analyser with Quiklyte ISE module at MRC Human Nutrition Research, Cambridge. This was shown to have a small negative bias for the Scotland 2009 samples relative to instruments providing accurate urinary sodium measurements as assessed by UK NEQAS; within acceptable limits for diagnostic purposes but not for assessment of population sodium intake and investigation of trends in this over time.
- A comparison study using over 200 urine samples was therefore conducted between the IL Flame Photometer, the Siemens Dimension Xpand and an instrument which performs accurately in UKNEQAS; correction factors were determined to enhance the accuracy of measurements of 24-hour urine sodium excretion in these surveys. For UK 2008, 24-hour excretions were corrected by multiplying by 0.952, and for Scotland 2009 by 1.052.
- Urinary sodium for the England 2006, Scotland 2006 and Wales 2007 surveys was measured using an ion-selective electrode on the Roche/Hitachi systems at the Doctors Laboratory, London. For these three surveys, a factor of 1.0 was determined (and applied to sodium data) from contemporaneous external quality assessment, not from a comparison study.

These corrected 24-hour excretions in the dataset ("UR24hNa_Johansson_adjusted_bias_corrected") should be used. The uncorrected concentrations "Na_mmol_raw" (as determined by the instrument) and uncorrected 24-hour sodium excretion "UR24hNa_raw" (calculated from this without correction of bias) are also included in the dataset, for completeness.

5.1 Notes about "adjustment" and "correction" of sodium data, and estimation of salt intake

In these datasets "Adjustment" of the 24-hour sodium excretion refers to the allowance made for marginal incompleteness of some 24-hour urine collections (PABA recovery of 70-84%[17]) which at the time of the survey was performed either by Johansson's formula[18] or using an unreferenced proportion formula; in this dataset the adjustment has been recalculated where necessary using the Johansson formula.[18] "Correction" refers to application of a factor to the sodium concentrations measured for all urines in individual surveys to allow for slight bias in some of the instruments used, in order to enhance between-survey comparability when differences are likely to be small.

Note that sodium data are archived without adjustment or correction, with relevant sodium results adjusted to allow for marginal incompleteness, and with all sodium data (after adjustment where necessary) corrected to allow for instrumental bias. The variable listing provides an explanation of the variables to help users distinguish between them.

Note that salt intake was calculated after, where appropriate, sodium concentration data were bias corrected and sodium excretion data were adjusted using the Johansson formula.[18] Salt intake was calculated using the equation:

Salt24h_intake = UR24hNa_Johansson_adjusted_bias_corrected / 17.1

6 Results included in the dataset

For the published assessment of dietary sodium,[4,5,6,7,8] only participants in the age range 19-64 years old with a complete 24-hour urine collection were analysed. These are identifiable in the dataset as 'UrineEligibilityCode = Complete'.

The archived dataset contains additional 279 individuals who were not included in the descriptive statistics tables or cumulative frequencies tables in the published survey reports as they either did not provide a complete 24-hour urine collection (n=275) or were outside the 19-64 years (n=4). These individuals are identifiable in the dataset as:

Incomplete collections (215 collections); 'UrineEligibilityCode = Incomplete'

Collections where the HPLC PABA % recovery was too high (21 collections); 'UrineEligibilityCode= HPLC PABA too high'

Collections where the urine volume was missing (2 collections); 'UrineEligibilityCode = Missing urine volume'

Collections where the PABA % recovery was missing (37 collections); 'UrineEligibilityCode = No PABA value'

Collections where the participants age was greater than 64 years (4 collections);

'Age < 19'

'Age > 64'.

It should be noted that the combined dataset includes participants with incomplete urine collections for some of the sodium surveys, and as such, certain results are not available for these participants. However unlike the other surveys, for the UK 2008 survey data are provided for incomplete collections for the variable 'Na_mmol_raw' (urinary sodium concentration (mmol/L) as measured by instrument - not bias corrected).

[1] Scientific Advisory Committee on Nutrition (2003). Salt and Health. The Stationery Office. http://www.sacn.gov.uk/pdfs/sacn_salt_final.pdf

[2] Accuracy and usefulness of select methods for assessing complete collection of 24-hour urine: a systematic review
Katherine A John, Mary E Cogswell, Norm R Campbell, Caryl A. Nowson, Branka Legetic, Anselm J N Hennis, Sheena m. Patel. Journal of Clinical Hypertension, Vol 18 May 2016 456-467

[3] Henderson L, Irving K, Gregory J, Bates CJ, Prentice A, Perks J, Swan G, Farron M. National Diet and Nutrition Survey: adults aged 19 to 64 years. Volume 3: Vitamin and mineral intake and urinary analytes. London: TSO, 2003.
http://webarchive.nationalarchives.gov.uk/20101211052406/http://www.food.gov.uk/science/dietarysurveys/ndnsdo cuments/ndnspreviousssurveyreports

[4] An assessment of dietary sodium levels among adults (aged 19-64) in the general population, based on analysis of sodium in 24 hour urine samples. England 2005/06 (published October 2006)
http://webarchive.nationalarchives.gov.uk/20101211052406/http://www.food.gov.uk/multimedia/pdfs/englandsodiu mreport.pdf

[5] Assessment of dietary sodium levels in the general population.
http://www.foodstandards.gov.scot/assessmentdietary-sodium-levels-general-population-scotland. Scotland 2006 Originally published March 2007, revised May 2011

[6] 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. 2006 (published Feb 2007).
http://webarchive.nationalarchives.gov.uk/20101211052406/http://www.food.gov.uk/multimedia/pdfs/walessodiumreport.pdf

[7] 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, (published June 2008);
http://tna.europarchive.org/20110116113217/http://www.food.gov.uk/multimedia/pdfs/08sodiumreport.pdf;

[8] A survey of 24 hour urinary sodium excretion in a representative sample of the Scottish population as a measure of salt intake. http://w ww.foodstandards.gov.scot/survey-24-hour-urinary-sodium-excretion-representativesample-scottish-population-measure-salt. 2009 (Published April 2011)

[9] https://www.gov.uk/government/statistics/national-diet-and-nutrition-survey-results-from-years-1-to-4-combined-of-the-rolling-programme-for-2008-and-2009-to-2011-and-2012

[10] https://www.gov.uk/government/publications/assessment-of-dietary-sodium-levels-among-adults-aged-19-64-in-england-2011

[11] https://www.gov.uk/government/statistics/national-diet-and-nutrition-survey-assessment-of-dietary-sodium-in-adults-in-england-2014

[12] http://www.foodstandards.gov.scot/national-diet-and-nutrition-survey-assessment-dietary-sodium

[13] https://www.food.gov.uk/northern-ireland/nutritionni/national-diet-and-nutrition-survey-assessment-of-dietary-sodium

[14] 448 adults provided a complete 24-hour sample, however 3 individuals outside the eligible age range had been included. Therefore there were only 445 complete collections from adults aged 19-64 years.

[15] https://discover.ukdataservice.ac.uk/Catalogue/?sn=8233&type=Data%20catalogue

[16] Fieldwork for the 2006 England study was conducted by nurses from NatCen. Fieldwork for the 2006 Scotland study was conducted by nurses from NatCen. Fieldwork for the 2007 Wales study was conducted by nurses from NatCen. Fieldwork for the 2008 UK study was conducted by nurses from NatCen. Fieldwork for the 2009 Scotland study was conducted by nurses from ScotCen.

[17] It should be noted that PABA recovery percentages are presented rounded to integers, however for the UK 2008 survey sodium excretion data were adjusted using unrounded PABA recovery percentages.

[18] Gunnar Johansson, Sheila Bingham and Marie Vahter Public Health Nutrition 2 587-591 (1999).