Public Health England

Protecting and improving the nation's health

National Diet and Nutrition Survey

Assessment of salt intake from urinary sodium in adults (aged 19 to 64 years) in England, 2018 to 2019

NatCen Social Research that works for society

MRC Epidemiology Unit

UNIVERSITY OF CAMBRIDGE

NIHR Cambridge Biomedical Research Centre

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Contents

Executive summary

There is an established relationship between salt intake and risk of high blood pressure (hypertension), which is a risk factor in the development of cardiovascular disease (CVD), such as heart disease and stroke.[1,2,3,4,5] High blood pressure affects approximately 31% of adults in England.[6] Evidence has shown that a reduction in salt intake leads to a lowering of blood pressure, particularly in people with hypertension, and is associated with a decrease in the incidence of CVD.[7]

The Scientific Advisory Committee on Nutrition (SACN) recommends a target reduction in the average salt intake of the UK population to a maximum of 6 g/day.[8] This level has been set as the UK government recommended maximum salt intake for adults and children aged 11 years and over. Following publication of the SACN Salt and Health report in 2003, the UK 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 for a range of food categories that contribute the most to the population's salt intakes and further revised in 2009, 2011 and 2014.[9]

In this 2018/19 survey, salt intake of adults aged 19 to 64 years in England was estimated from the measurement of 24-hour urinary sodium excretion. Urine samples were collected between November 2018 and May 2019 from 596 adults. Estimated salt intake was calculated based on 17.1 mmol of sodium equalling 1.0 g of salt and assumed all urinary sodium was derived from salt and 100% was excreted over 24 hours. Completeness of the urine collections was assessed using the *para*-aminobenzoic acid (PABA) method. The survey was powered to detect a 7% decrease in salt intake (equivalent to 0.5 g/day) between the most recent previous England Sodium Survey in 2014 and the current survey in 2018/19. This data helps to establish progress towards meeting the government recommendation[8] and build on the series of previous surveys across the UK since 2005/06.[10,11,12,13,14,15,16,17,18]

This report describes population mean estimated salt intake for adults aged 19 to 64 years in England in 2018/19 and provides a comparison with estimated population salt intakes assessed in the previous 2014 England Sodium Survey.[12] An updated analysis of the trend in estimated salt intake over time since 2005/06 is also provided.

Main findings

The arithmetic means (including their comparisons with the government recommendation on salt intake) are presented here as they have been in all previous reports. However, due to the skewed distribution of this data, the geometric mean has been included as an alternative to the arithmetic mean and has been used for analysis of changes over time.[i]

In 2018/19, the arithmetic mean estimated salt intake for adults aged 19 to 64 years was 8.4 g/day (40% higher than the government recommended maximum of 6 g/day); 9.2 g/day for men and 7.6 g/day for women. As in previous surveys, the distribution of estimated salt intake among the adult population aged 19 to 64 years was wide; the 2.5th and 97.5th percentiles were 2.7 g/day and 17.8 g/day.

No statistically significant changes in salt intake were seen between 2014 and 2018/19[ii].

The trend analysis results showed a statistically significant downward step-change in estimated salt intake between 2005/06 and 2008/09.[ii] There were no significant step changes after 2008/09. For men and women combined, the linear trend from 2008/09 to 2018/19 was close to zero, indicating no change in estimated population salt intake over this period.

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[i] See appendix A, section A.10 for an explanation of arithmetic and geometric means.
[ii] Analysis based on geometric means.

1. Introduction

This report provides data to determine progress towards meeting the government recommendation to reduce the average population salt intake in England to a maximum of 6 g per day (g/day).[8] It builds on the series of previous sodium surveys reporting estimated salt intake in the general adult population (19 to 64 years) in England,[10,11,12] Wales,[13] Scotland,[14,15,16], Northern Ireland[19] and across the UK.[17]

Dietary salt is the predominant source of sodium in the UK diet. As the majority (93%) of ingested sodium is excreted in urine, intake can best be assessed by measuring sodium excretion in urine.[20] This method is considered more reliable than dietary assessment methods because of the known limitations in self reporting and quantifying discretionary salt used in cooking and prior to the consumption of food.[7]

A 24-hour urine collection method, validated by the *para*-aminobenzoic acid (PABA) method (see chapter 2, section 2.5.1), was used for this survey, consistent with the previous UK government sodium surveys.[10,11,12,13,14,15,16,17,19] This method is accepted as being the most reliable method for estimating salt intake in the population.[iii,21]

This report presents the results of the 2018/19 England Sodium Survey and provides an update to the trend analysis performed in 2014 of estimated salt intake over time for England since 2005/06.[12]

1.1 Background

There is an established relationship between salt intake and risk of high blood pressure (hypertension), which is a risk factor in the development of cardiovascular disease (CVD), such as heart disease and stroke, in the UK and globally.[1,2,3,4,5] Approximately 31% of adults in England have high blood pressure[6] and overall, high blood pressure is the third largest risk factor for premature death and disability in England.[22]

Despite a downward trend in CVD mortality in the UK since the 1980s, CVD remains a leading cause of mortality and morbidity.[23] The British Heart Foundation estimated that in England, around 6.1 million people live with CVD.[4]

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

[iii] The level of sodium in urine fluctuates according to what was eaten at the last meal and how much fluid an individual had drunk. Assessments based on a 24-hour collection are more accurate than a single spot sample, which are not recommended for population-level assessment of salt intake.

Nutrition Policy's (COMA) cardiovascular review group recommended that population average salt intake should be gradually reduced to 6 g/day or less for adults from the then average 9 g/day salt intake.[24] In 2003, the Scientific Advisory Committee on Nutrition (SACN) published its report 'Salt and Health' that endorsed COMA's recommendation for a maximum of 6 g/day.[iv,8] These values are broadly comparable with those published by the World Health Organization (5 g/day)[25] and with the 'chronic disease risk reduction level' published in 2019 by the National Academies of Sciences, Engineering, and Medicine for the USA and Canada (sodium 2,300 mg/day equivalent to salt intake of 5.85 g/day).[7] It is estimated that a population average reduction of 1 g/day in salt intake could prevent 4,147 premature deaths each year and save the NHS £288 million annually.[22]

Following the publication of the SACN report in 2003, the UK government began a programme of work aimed at reducing salt intakes across the population. The 2003 SACN report noted that a reduction in the salt content of processed foods would be necessary to achieve the target recommendation to reduce population salt intakes to a maximum of 6 g/day (5 g/day for women; 7 g/day for men).[8] Efforts to reduce salt intakes across the population have included work with the food industry from the mid-2000s to reduce the salt content of processed food products. Voluntary salt reduction targets were first set in 2006 for a range of food categories that contribute the most to the population's salt intakes. To date, 4 sets of targets have been published by government (2006, 2009, 2011 and 2014) to guide industry (including out of home food providers) in product reformulation and in the reduction of the amount of salt in processed foods across a wide range of food categories.[v,26]

Evidence suggests initial success in reducing salt levels in a range of foods including bread, the largest contributor of salt in the UK diet, for which the salt content was reduced by about 20% from 2001 to 2011.[27] However, a detailed assessment of further progress published in 2018 showed a mixed picture in relation to meeting the 2017 salt reduction targets for manufactured foods; for foods purchased for consumption in-home (retailer and manufacturer products), just over half of average salt reduction targets were met and 81% of products met the maximum targets. Seventy-one percent of out of home sector products were at or below maximum per serving targets which were set specifically for this sector.[9]

Dietary modification is a key component in preventative strategies to reduce the risk of CVD. Public health awareness campaigns are used by government to give the population access to information (including front-of-pack labelling) needed to make

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[iv] The SACN (2003) recommendation is no more than 5 g/day of salt intake for women and no more than 7 g/day of salt intake for men and a maximum salt intake of 6 g/day for the population, men and women combined.

[v] Examples of food categories include meat products, bread and cereals, dairy products, ready meals, condiments and sauces.

informed choices. A public awareness campaign was a key element of salt reduction activities from 2004 to 2009.[28] More recently, the national campaign Change4Life, launched in 2009, focuses on promoting a healthy lifestyle through healthier choices including salt reduction and physical activity.[29]

In 2014, PHE formed the Blood Pressure System Leadership Board and brought together stakeholders from across national and local government, the health system, voluntary and community sector and academia to consider strategies to improve the prevention, detection, management and reduction of inequalities related to blood pressure.[30] Reduction of salt intake was confirmed as a major priority.[30,31]

Prior to this report, there have been 4 sodium surveys of representative samples of adults aged 19 to 64 years in England, all using 24-hour urine collections.[10,11,12,17] As reported in the trend analysis carried out for the 2014 England Sodium Survey, there was evidence of a significant reduction in population salt intakes between 2005 and 2006 and 2008 and 2009 but no evidence of a statistically significant downward linear trend or further significant step changes in the period between 2008 and 2009 and 2014.

1.2 Aims of the survey

The overarching aim of this survey was to measure progress towards the government's recommendation to reduce the average population salt intake in England to a maximum of 6 g/day.

The specific aims of the survey were to:

- assess urinary sodium excretion (to estimate daily dietary salt intake) in adults aged 19 to 64 years living in England in 2018/19 by collecting and analysing 24-hour urine samples for a representative sample of the population
- compare estimated salt intake from this survey (England 2018/19) with the previous survey in England (2014)[12]
- update the trend analysis in estimated salt intake (g/day) based on data collected from the:
  - England sodium surveys carried out between 2005/06 and 2014[10,11,12,17]
  - National Diet and Nutrition Survey Rolling Programme (NDNS RP) collected between 2008/09 and 2012/13,[32] and
  - the current survey (2018/19).

This report presents the results of the 2018/19 England Sodium Survey, compares the 2018/19 data to the 2014 England Sodium Survey and provides an update to the trend analysis performed in 2014 that considered the change in salt intake over time since the survey in 2005/06.

Ethical approval for the survey was granted by the East Midlands – Derby Research Ethics Committee (Ref. No. 18/EE/0241).

The survey was carried out by NatCen Social Research (NatCen) and the National Institute of Health Research Cambridge Biomedical Research Centre (referred to as Cambridge BRC NDNS team in this report). The latter consists of the NIHR BRC Diet, Anthropometry and Physical Activity Group and the NIHR BRC Nutritional Biomarker Laboratory hosted at the Medical Research Council Epidemiology Unit at the University of Cambridge. The survey was funded by PHE.

2. Methodology

This chapter provides an overview of the methodology for the 2018/19 England Sodium Survey. The methodology outlined in this chapter is consistent with previous surveys, unless stated otherwise.

2.1 Sample design

The aim was to obtain 565 complete 24-hour urine collections over a seven-month period (November 2018 to May 2019). The survey was designed to be:

- representative of the population aged 19 to 64 years living in England, and
- able to detect a reduction of 7% in the geometric mean estimated salt intake compared with the previous survey in 2014 – this 7% reduction is equivalent to a reduction of approximately 0.5 g/day in salt intake based on the England 2014 survey[12]

To enable this, a power calculation was performed. It was calculated that 565 complete 24-hour urine collections were required to detect a 7% reduction in geometric mean estimated salt intake between the 2014 and 2018/19 England Sodium Surveys (see section 2.7 for an explanation of means).[vi] This reduction is equivalent to a reduction of approximately 0.5 g/day in salt intake based on the 2014 England Sodium Survey.[12] Participants were sampled from the Health Survey for England (HSE) 2017 cohort.[vii] The HSE sample was designed to be representative of the population living in private households in England. Full details of the HSE sample design are reported in the Health Survey for England 2017 Methods Report.[33] Individuals in the required age range who, at the time of their HSE 2017 interview, consented to be contacted for follow-up research and provided a telephone number for this purpose were included in the sample for the 2018/19 England Sodium Survey. In each household, up to 2 individuals fulfilling the above eligibility criteria were selected to participate.

In total, 3,575 individuals across 2,540 households were included in the sample for the 2018/19 England Sodium Survey. This sample size was calculated using the number of completed 24-hour urine collections required and estimated dropout rates at each stage of fieldwork.[viii]

[vi] To achieve 80% power and assuming a statistical significance level of 5%.

[vii] Previous standalone sodium surveys in England (2011, 2014) used a sample design based on Random Digit Dialling. See the relevant reports for full detail of the methodology.[12,17]

[viii] These estimates were informed by experience of the previous surveys.

2.2 Participant recruitment

The 3,575 individuals (in 2,540 households) identified from HSE 2017 as being eligible (see section 2.1) were sent an advance letter inviting them to take part in the 2018/19 England Sodium Survey.[ix] NatCen's Telephone Unit (TU) interviewers attempted to contact the 2,540 sampled households to introduce the survey and check the eligibility of individuals. If the individual(s) were deemed eligible (that is aged 19 to 64 years, had not moved home, were not pregnant/breastfeeding and no language barriers prevented them from participating), the interviewer then sought their willingness to take part in the survey and confirmed agreement for a NatCen nurse to make contact to arrange a home visit for collection of the 24-hour urine sample(s).

The nurse made initial contact with willing participant(s) via telephone and arranged a suitable appointment date and time for a visit. 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 instructions, and the second visit to measure the total urine collection volume and take a subsample for despatch to the laboratory for analysis.

Survey documents can be found in appendix D of this report.

2.3 Urine collection protocol

After obtaining written consent (see appendix A), the nurse instructed participants in the 24-hour urine protocol. Participants were asked to collect all urine during a 24-hour period starting from the second morning urine pass of the 24-hour collection day, until and including the first urine pass the following morning. The nurse used the Computer Assisted Personal Interview (CAPI) programme to randomly allocate a day of collection for the participant. If the allocated date was unsuitable for the participant, CAPI would randomly allocate an alternative start day. Nurses would discuss the allocation of the collection day with participant to emphasise the importance of the representativeness of the survey across the whole week. However, in order to maximise the number of samples collected, participants were allowed to collect their sample on the day of their choice if the allocated day was inconvenient or unsuitable. Women were guided to collect their urine when they were not menstruating, however samples were accepted if collected during menstruation.

[ix] The survey was referred to in the field as the "Diet and Health Study" to minimise the risk of participants changing their diets.

Participants were provided with the necessary equipment to do the 24-hour collection and were asked to take 3 PABA tablets at evenly spaced intervals[x] throughout the day of the collection to check the completeness of the collection (see appendix A). Participants were still eligible to take part if they were willing to carry out the 24-hour urine collection but could not (or did not want to) take PABA.[xi] 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 appendix A for more details). The nurse revisited participants on the day or the day after the 24-hour urine collection was completed to pick up the samples, complete paperwork and send to the Cambridge BRC NDNS team for analysis. The nurse thoroughly mixed the urine collection before weighing. Urine was weighed using Salter Breknell ElectroSamson digital handheld scales in order to determine total urine volume. The nurse collected 2 samples from the mixed, total 24-hour urine collection 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 Cambridge BRC NDNS team.

2.4 The household questionnaire

During the urine sample collection visit the nurse administered a short CAPI questionnaire to collect information about occupational status, household composition and knowledge, attitudes and practices around dietary salt.

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

2.5 Urinary sodium measurement and analytical laboratory procedures

Methods are outlined in the following sections. Full detail is provided in appendix B.

2.5.1 Assessment of completeness of 24-hour urine collection

The accurate assessment of dietary sodium intake relies upon the complete collection of urine by participants over a full 24-hour period. This was facilitated by use of the PABA method (for participants who agreed to take PABA), thorough training of nurses and explanation to participants, and detailed recording by participants of urine collection timings and missed collections.

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[x] Participants were asked to take the first tablet at the beginning of the collection period and the following 2 tablets 4-6 hours after the previous tablet.

[xi] Participants who were allergic to vitamin preparations, hair dyes or sunscreen lotions were ineligible to take PABA.

Completeness of 24-hour urine collections was assessed by measuring concentration of PABA in the urine, as described in appendix B. Where participants reported taking the three 80 mg PABA tablets at appropriate intervals, 24-hour urine collections were considered to be complete if they contained between 70% and 103% of the PABA and the recorded urine was within 20 to 28 hours.[20]

Urine collections with a PABA recovery under 70% were considered incomplete, while those with a PABA recovery greater than 103% were considered unfeasibly high and therefore unreliable. Complete collections (those with a PABA recovery of between 70% and 103% of the PABA) were included in the results, while collections deemed incomplete or unreliable were excluded.

Samples from individuals who elected not to take PABA, or who reported they did not take all 3 PABA tablets, but recorded they had completed a 24-hour urine collection with no reported missed urine with collection time between 23 and 25 hours were included.[xii,20] Such individuals with collection times outside of the 23 to 25 hours were excluded from further data analysis and were not included in the results.

2.5.2 Analytical methods

Measurement of PABA was performed by the Cambridge BRC NDNS team by high performance liquid chromatography (HPLC), based on a published method with modifications.[34,35]

Measurement of urinary sodium[xiii] was performed using ion selective electrode (ISE) technology on the Roche Cobas C111 analyser (Roche Diagnostics Ltd, Burgess Hill, UK).

2.5.3 Calculation of estimated dietary salt intake

Sodium concentration in urine was measured in units of mmol/L. The total amount of sodium excreted over 24 hours (mmol/24 h) was calculated by multiplying the sodium concentration by total urine volume to provide sodium excretion per 24 hours. There was no adjustment of total sodium excretion to account for small differences in reported duration of urine collection.

[xii] No correction factors were applied to sodium concentration data based on PABA recovery.

[xiii] Urinary potassium concentration was also measured. Data is not presented in this report but will be available via the UK Data Service.

In line with previous sodium surveys in the UK, estimated dietary salt intake was then calculated using the equation:

- 17.1 mmol of sodium = 1.0 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.

2.6 Methodological differences: comparisons with previous England surveys included in trend analysis

Laboratory methods for the assessment of urinary sodium concentration and PABA concentration have evolved over time and consequently different surveys at different times in the UK have used different methods. The analytical methods used in the sodium surveys included in the trend analysis described in this report are summarised in table 2A.

With the exception of the 2008 UK Sodium Survey[17] that measured urinary sodium with flame photometry, all sodium surveys from 2005/06 onwards have used ion selective electrode (ISE) technologies to measure urinary sodium. At the time of the 2014 England Sodium Survey, urinary sodium concentrations from some of the previous surveys that used different laboratory analytical methods were adjusted using factors to take account of method-specific analytical biases so that the results were more directly comparable between surveys[12] (see appendix B, section B.4).

Method-specific correction factors were applied to align sodium concentration results with the all laboratory trimmed mean (ALTM)[xiv] established by the UK National External Quality Assessment Scheme (UK NEQAS). To enable comparison between the different survey datasets the previously harmonised data has been used in analyses for this report.[xv]

For the 2018/19 survey, a cross-validation was performed to assess the comparability of urinary sodium concentration results reported for the 2014 England Sodium Survey against data obtained from the re-analysis of 120 urine samples from the 2014 England Sodium Survey measured using a Roche Cobas C111 analyser used by the Cambridge BRC NDNS team. The cross-validation demonstrated excellent comparability between the results and therefore no further method-specific correction factor was required.

[xiv] The All Laboratory Trimmed Mean is the geometric mean of the entire set of trimmed results for a specimen. Results are trimmed (removing the lowest and highest 5% of results) to minimise the effect of aberrant results.

[xv] Method-specific correction factors were derived and applied by the group responsible for the 2014 England Sodium Survey. These are detailed in the National Diet and Nutrition Survey: assessment of dietary sodium; Adults (19 to 64 years) in England, 2014 report.[12]

A detailed description of precision and accuracy for the 2018/19 survey is provided in appendix B, section B.4.

Table 2A. Summary of analytical methods for sodium and PABA analysis[a] in the England sodium surveys

<table>
<tr><th>Survey[b]</th><th>n</th><th>Method (instrument) of sodium analysis and [laboratory]</th><th>Identification of complete collections</th><th>Group for trend analysis</th></tr>
<tr><td>England Sodium Survey 2005/06</td><td>445</td><td>ISE (Roche/Hitachi) [The Doctors Laboratory in London (TDL)]</td><td>PABA (colorimetry/HPLC)</td><td>1</td></tr>
<tr><td>UK Sodium Survey 2008[b]</td><td rowspan="2">688</td><td>Flame photometer (IL 943) [MRC HNR]</td><td>PABA (colorimetry/HPLC)</td><td>2</td></tr>
<tr><td>NDNS RP Y1 2008/09[b]</td><td rowspan="7">ISE (Siemens Dimension Xpand) [MRC HNR]</td><td rowspan="2">PABA (colorimetry/HPLC) or participant claim</td><td>2</td></tr>
<tr><td>NDNS RP Y2 2009/10[b]</td><td>109</td><td>3</td></tr>
<tr><td>NDNS RP Y3 2010/11[b]</td><td>109</td><td rowspan="6">PABA (HPLC) or participant claim</td><td>4</td></tr>
<tr><td>NDNS RP Y4 2011/12[b]</td><td rowspan="2">725</td><td>5</td></tr>
<tr><td>England Sodium Survey 2011</td><td>5</td></tr>
<tr><td>NDNS RP Y5 2012/13</td><td>155</td><td>6</td></tr>
<tr><td>England Sodium Survey 2014</td><td>689</td><td>7</td></tr>
<tr><td>England Sodium Survey 2018/19</td><td>596</td><td>ISE (Roche Cobas C111) [Cambridge BRC NDNS team]</td><td>8</td></tr>
</table>

[a] Table adapted from the 2014 Sodium Survey Report[12]

[b] Where the source was a UK survey, only England data have been presented

Abbreviations: HPLC, high performance liquid chromatography; ISE, ion-selective electrode; MRC HNR, Medical Research Council, Human Nutrition Research; Cambridge BRC NDNS team, NIHR BRC Nutritional Biomarker Laboratory, University of Cambridge, University of Cambridge; NDNS RP, National Diet and Nutrition Survey Rolling Programme; PABA, *para*-aminobenzoic acid.

The trend analysis is based on data for England only and takes into account all the individual data points (rather than survey grouped means). Each of the surveys had a complex sample design for which their stratification and clustering were taken into account in this analysis. Survey data was combined according to discrete survey time periods. In instances where 2 surveys were combined into a single survey year, the sampling weights for each survey were combined using the 'combining sample weights' approach detailed in O'Muircheartaigh et al., 2002.[36] (see table 2A for surveys included). As mentioned above, the analyses in this report use urinary sodium concentrations from previous surveys, some of which have been adjusted using factors applied at the time of the 2014 England survey, to take account of method-specific analytical biases.[12]

2.7 Statistical methodology

This report presents summary data using both arithmetic and geometric means of urinary sodium excretion and estimated salt intake data. Arithmetic means are presented in this report, as in previous reports, for comparison with the 6 g/day maximum recommendation. Urinary sodium excretion and salt intake data have a positively skewed distribution and so geometric means have been used for analysis of changes over time as these are less influenced by high values and provide a better representation of the typical value (see appendix A, section A.10 for more details).

2.7.1 Peer review of statistical approach

The statistical approach to data presentation and analysis for the 2018/19 survey was externally peer reviewed ahead of results analysis. The peer review endorsed the recommendation that geometric means rather than arithmetic means should be presented and used to evaluate relative changes in the data between years or groups (see separate document, Peer Review Annex).

2.8 Considerations for data interpretation

The following should be considered when interpreting the data.

1. 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.
2. A single 24-hour urine collection from an individual provides a data point describing the population (group) distribution. Sodium excretion is influenced by multiple factors including habitual and recent salt intake as well as hormonal and other physiological factors. Multiple 24-hour urine collections from the same individual would be required to reliably assess an individual's habitual salt intake, therefore measured sodium excretion from a single 24-hour collection is not a marker of habitual salt intake at the individual level.
3. Laboratory methods for the measurement of sodium have evolved over time and different surveys have consequently used different methods. As far as possible these differences have been accounted for retrospectively using method-specific correction factors (applied in 2014) to allow for combination of data from different surveys for trend analysis.[12] No correction factors were applied to the 2018/19 data.
4. Study design and methods used to define a 24-hour urine collection as complete have evolved over time and are difficult to fully harmonise.
5. Participants for the current 2018/19 survey were recruited from the HSE 2017 cohort. For previous sodium surveys (2011 and 2014), Random Digit Dialling

(RDD)[xvi] was used to recruit participants.[xvii] For all surveys, data were weighted to minimise bias in the observed results. Whilst sex and age characteristics of this cohort were similar to previous surveys it is likely that some inherent variation may exist between data collected in different surveys that cannot be accounted for by weighting.

6. As in previous surveys, the number of people in the youngest age group (19 to 34 years) providing 24-hour urine collections was lower than amongst adults aged 35 to 64 years.
7. Samples in the 2018/19 survey were collected during November 2018 to May 2019. In the 2014 survey samples were collected from May to November. Earlier surveys used different collection periods[xviii].
8. For reporting purposes, summary data is provided using both arithmetic and geometric means. 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 between groups and to minimise bias from the skewed data.

[xvi] RDD is a method where a representative sample of landline telephone numbers is generated at random from a frame of all possible telephone numbers.
[xvii] Participants for the 2005/06 survey were recruited from HSE 2005.
[xviii] Visual inspection of geometric mean estimated salt intake for the 2014 and 2018/19 surveys by month did not suggest any clear seasonal differences in salt intake.

3. Response and weighting

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

3.1 Response

In total, 3,575 individuals (in 2,540 households) who had taken part in HSE 2017 were issued to NatCen's Telephone Unit (TU) interviewers for recruitment to the 2018/19 England Sodium Survey. Of these, 10% (353) did not have useable telephone numbers and interviewers were unable to make contact and establish eligibility with 24% (851). Contact was made with 66% (2,371) of the individuals issued to the TU.

Of the 2,371 individuals successfully contacted by the TU, 9% (225) were unable to take part in the 2018/19 England Sodium Survey as they had moved home[xix] and 2% (36) were ineligible as they were pregnant/breastfeeding or language barriers would prevent them from providing informed consent. A further 2% (49) were unable to take part due to other reasons including illness or being away during the fieldwork period.

In total, 2,061 individuals were eligible to take part. Of these, 41% (835) declined to take part and 59% (1,226) agreed to be contacted by a nurse.[xx]

(Table 1)

As well as those who agreed to nurse contact,[xxi] an additional 77 adults who originally declined to take part were issued to nurses. These were individuals in households where the other selected adult had agreed to nurse contact. The nurse was provided with details of both individuals so they could then take part if they wished to do so.

A total of 1,301 individuals (898 households) were issued to nurses (566 men, 735 women). Of those issued 72% of households (933 individuals) were visited. A further 12% (153) declined to take part, 1% (14) could not be contacted despite repeated attempts and 15% (201) were not visited for other reasons.[xxii] In total, 96% (897) of

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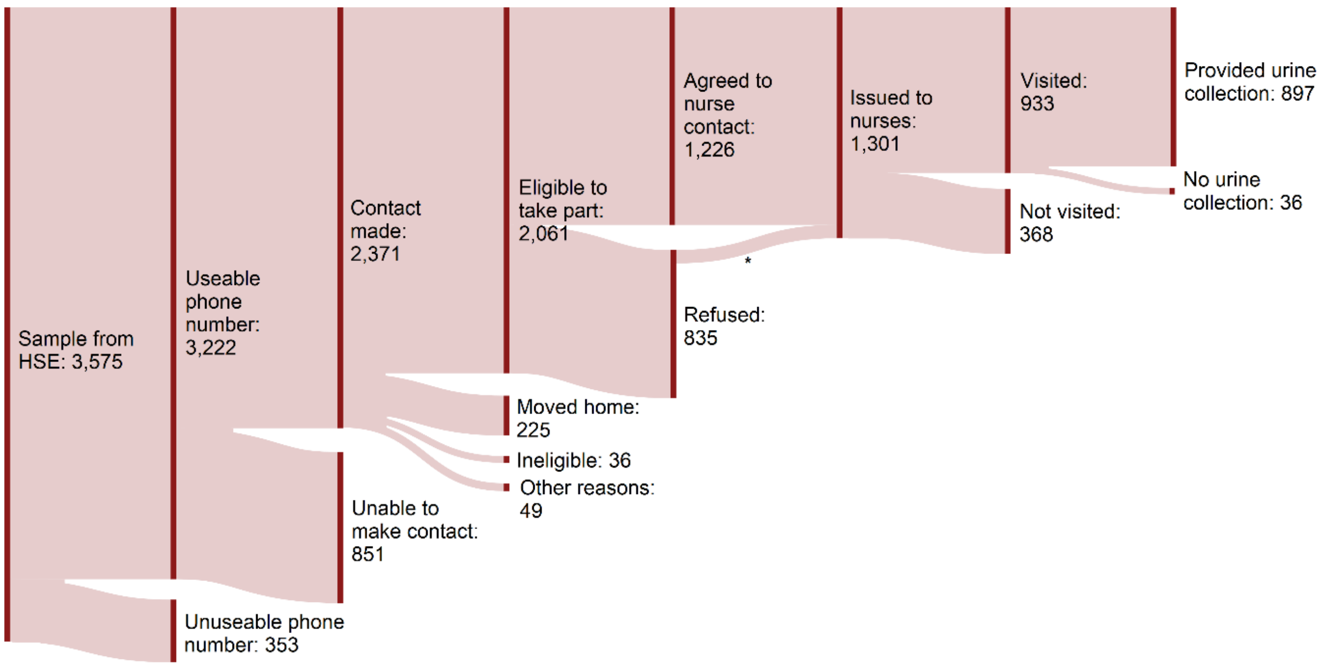
[xix] For fieldwork management reasons, individuals who had moved since their HSE 2017 interview were not followed up at their new address.
[xx] For fieldwork management reasons, 2 of the 1,226 cases were removed from the sample before being issued to a nurse.
[xxi] 1,224 individuals after the removal of the 2 cases.
[xxii] Other reasons include individuals coded as ill during fieldwork period, away during fieldwork period, pregnant and broken appointments.

individuals visited by a nurse provided a 24-hour urine collection. This equates to 69% of individuals issued to nurses providing a 24-hour urine collection.

(Table 2)

Figure 3.1: Stages of participant recruitment



*For fieldwork management reasons, 2 cases were removed from the sample before being issued to a nurse. An additional 77 adults who originally declined to take part were issued to nurses. These were individuals in households where the other selected adult had agreed to nurse contact.

3.2 Number of useable urine collections

Of the 897 urine collections provided, 380 were from men and 517 were from women. One sample was lost in transit and 24 were outside of the required collection window (less than 20 or greater than 28 hours) and were disposed of by the nurse. The total number of urine collections received by the Cambridge BRC NDNS team was 872 (369 from men, 503 from women). Seven samples were subsequently excluded from the analysis due to reported collection time discrepancies and missing urine volume information.

Of the 865 urine collections analysed for completeness, 596 (67%) were deemed ‘complete’ (useable) and 269 (33%) were deemed as incomplete or unreliable (see appendix A, section A.8). Of the urine collections deemed ‘complete’ 43% (286) were from men and 57% (310) were from women. The sex and age profile of participants providing complete urine collections was skewed towards women and older individuals. This is similar to previous sodium surveys and is accounted for in the weighting (see appendix A, section A.9).

(Tables 3 & 5)

3.3 Urine collection days

Overall, 57% (341) of urine samples were collected on a weekday (Monday to Friday) and 43% (255) were collected at the weekend; this distribution was similar to previous surveys.

(Table 4)

3.4 Weighting

The data was weighted to minimise any bias in the observed results that may be due to differences in the probability of individuals within a household being selected to take part; and the likelihood that an individual would participate (see appendix A, section A.9 for detail of the weighting strategy).

4. Urinary sodium excretion and estimated salt intake

4.1 Sodium excretion and estimated salt intake

Data in tables 6 and 8 are presented as arithmetic mean with standard deviation and geometric mean with 95% confidence interval (CI). The lower (2.5th) and upper (97.5th) percentiles are also presented.

As in previous surveys, there was a wide distribution of estimated salt intakes and high values in some individuals that led to a positively (right-) skewed distribution (see chapter 2, section 2.7).

4.2.1 Sodium excretion in 2018/19

Table 6 provides mean urinary sodium excretion by sex expressed as mmol/24 h and table 7 shows the cumulative percentage distribution of urinary sodium excretion by sex/age group.

The arithmetic mean for urinary sodium excretion for adults was 143 mmol/24 h; 157 mmol/24 h for men and 130 mmol/24 h for women.

The geometric mean urinary sodium excretion was 128 mmol/24 h in adults; 142 mmol/24 h for men and 117 mmol/24 h for women.[xxiii]

(Table 6)

4.2.2 Estimated salt intake in 2018/19

Table 8 provides mean estimated salt intake by sex and age group expressed as g/day and table 9 shows the cumulative percentage distribution of estimated salt intake.

The arithmetic mean estimated salt intake for adults aged 19 to 64 years in this survey was 8.4 g/day, 40% higher than the government recommendation of the population

[xxiii] To convert to mg, mmol sodium is multiplied by 23. Consequently, geometric means of sodium excretion were 2954, 3256 and 2680 mg/24 h in adults, men and women, respectively.

average of no more than 6 g/day.[xxiv] Men had a mean estimated daily intake of 9.2 g/day and women had a mean estimated daily intake of 7.6 g/day. In the age groups (men and women combined) 19 to 34 years, 35 to 49 years and 50 to 64 years, values were 8.4 g/day, 9.0 g/day and 7.7 g/day, respectively.

As described above, the geometric mean provides a more appropriate estimate of the 'typical value' for a population where the distribution of values is positively skewed. In adults, the geometric mean estimated salt intake was 7.5 g/day. In men, the geometric estimated mean was 8.3 g/day and in women 6.8 g/day. In the age groups (men and women combined) 19 to 34 years, 35 to 49 years and 50 to 64 years, values were 7.6 g/day, 8.0 g/day and 7.0 g/day, respectively.

As in previous surveys, there was a wide distribution of estimated daily salt intake: the 2.5th and 97.5th percentiles were 2.7 g/day and 17.8 g/day in adults (3.2 and 20.8 g/day in men; 2.3 and 14.8 g/day in women). Overall, 69% of the estimates were higher than the population target maximum of 6 g/day.

(Tables 8 and 9)

4.3 Estimated salt intake in 2018/19 compared with 2014

No statistically significant changes in salt intake were seen when 2014 and 2018/19 results were compared. Observed estimated daily salt intake was higher in adults (men and women combined) in this survey compared with the 2014 survey (geometric mean 7.5 g/day compared to 7.2 g/day respectively), but this difference was not statistically significant. However, the data was not consistent between men and women. For men, estimated geometric mean daily salt intake was 8.3 g/day in 2018/19 compared to 8.5 g/day in 2014, and for women, the figures were 6.8 g/day in 2018/19 and 6.2 g/day in 2014. Neither of the observed changes for men or women were statistically significant.

(Table 10)

[xxiv] The population target maximum salt intake is 6 g/day for adults (5 g/day for women and 7 g/day for men).

5. Estimated salt intake trend analysis (2005/06 and 2018/19)

The objective of the updated salt intake trend analysis was to estimate the change in salt intake in England between 2005/06, the first assessment after salt reduction work began, and the most recent assessment in 2018/19.

The trend analysis allows quantification of the average yearly percentage change in estimated salt intake and the average percentage change over the range of years of the sodium surveys along with 95% confidence intervals for these changes.

Trend analysis was performed using a linear regression model, including sex and age as covariates, and using log-transformed salt intake data. Log-transformed salt intake did not follow a linear relationship over the full date range of sodium surveys (2005/06 to 2018/19) so step changes between successive survey years were assessed using 2-sample t-tests. The linear regression analysis was repeated excluding the 2005/06 sodium survey to assess the trend from 2008/09 to 2018/19.

5.1 Trend analysis results 2005/6 to 2018/19

In table 5A a summary of estimated daily salt intakes for each survey from the 2005/06 England survey onwards are provided.

Table 5A. Number of participants and geometric mean of estimated salt intake (g/day) in England between 2005/06 and 2018/19

Survey group	Combined		Men		Women	
	n	Geometric mean (g/day)	n	Geometric mean (g/day)	n	Geometric mean (g/day)
2005/06	445	8.1	187	9.3	258	7.1
2008/09	688	7.5	301	8.5	387	6.7
2009/10	109	7.4	50	8.7	59	6.2
2010/11	109	6.9	56	8.6	53	5.6
2011/12	725	7.7	325	8.9	400	6.7
2012/13	155	7.0	60	7.7	95	6.4
2014	689	7.2	298	8.5	391	6.2
2018/19	596	7.5	286	8.3	310	6.8

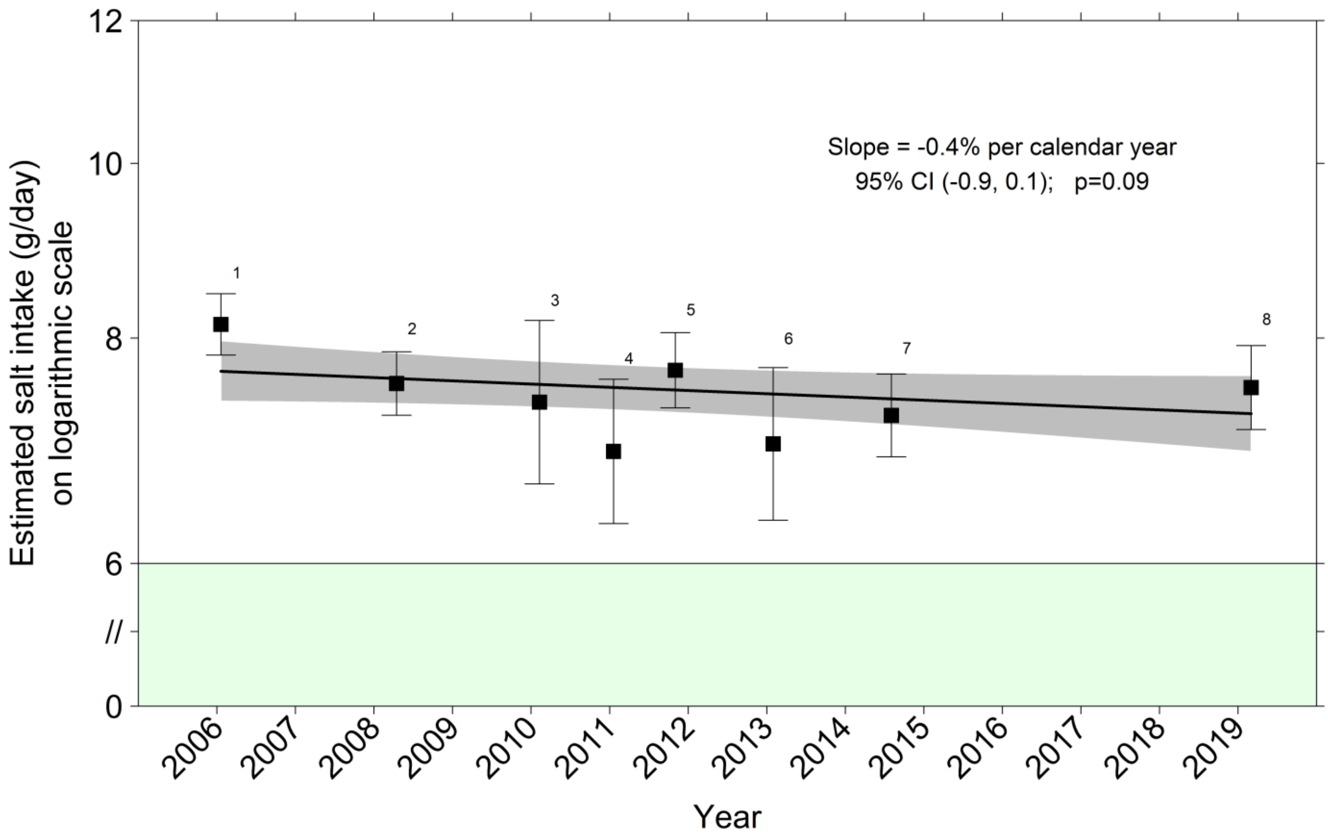
Average percentage changes for adults aged 19 to 64 years and for men and women separately between 2005/06 and 2018/19 are shown in table 5B. Survey geometric means and trend lines are plotted in figure 5.1 for all participants and figure 5.2 for men and women separately along with the population target maximum intake for women (5 g/day) and for men (7 g/day).[8]

The trend analysis between 2005/06 and 2018/19 indicated no statistically significant linear change in estimated daily salt intake over time. The slightly higher estimated salt intake for all adults in the 2018/19 survey has resulted in a lower average change than was reported in the 2014 England Sodium Survey trend analysis (11% from 2005/06 to 2014 which was statistically significant).

Table 5B. Trend analysis results showing average percentage change in estimated daily salt intake in England between 2005/06 and 2018/19

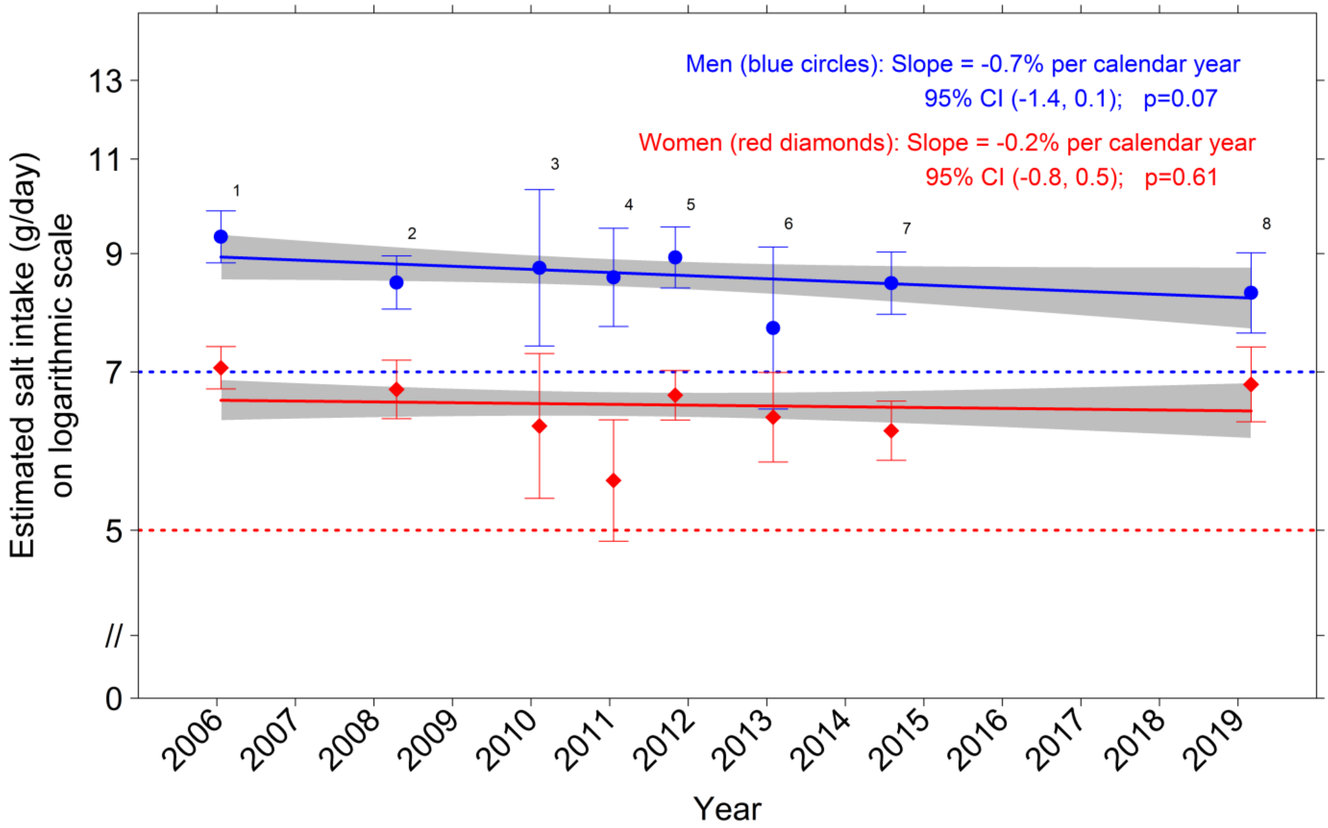
	Average yearly percentage change in estimated salt intake (95% CI)	Average 13-year percentage change in estimated salt intake (95% CI)
All participants	-0.4 (-0.9, 0.1)	-5.3 (-11.1, 0.9)
Men	-0.7 (-1.4, 0.1)	-8.3 (-16.6, 0.8)
Women	-0.2 (-0.8, 0.5)	-2.2 (-10.3, 6.6)

Figure 5.1. Trend in estimated salt intake (g/day) for adults aged 19 to 64 years in England between 2005/06 and 2018/19 (geometric means with 95% confidence intervals)



Numbers on chart indicate survey group: 1: England 2005/06 (n=445); 2: UK 2008 (England) and NDNS RP (England) Year 1 (n=688); 3: NDNS RP (England) Year 2 (n=109); 4: NDNS RP (England) Year 3 (n=109); 5: England 2011 and NDNS RP (England) Year 4 (n=725); 6: NDNS RP (England) Year 5 (n=155); 7: England 2014 (n=689); 8: England 2018/19 (n=596).
A break has been added to the vertical axis between 0 and 6 g/day.
The population target maximum for salt intake is 6 g/day and is indicated in green.
The grey shaded region indicates the 95% confidence interval for the regression line.

Figure 5.2. Trend in estimated salt intake (g/day) for men and women aged 19 to 64 years in England between 2005/06 and 2018/19 (geometric means with 95% confidence intervals)



Numbers on chart indicate survey group: 1: England 2005/06 (n=187 men, 258 women); 2: UK 2008 (England) and NDNS RP (England) Year 1 (n=301 men, 387 women); 3: NDNS RP (England) Year 2 (n=50 men, 59 women); 4: NDNS RP (England) Year 3 (n=56 men, 53 women); 5: England 2011 and NDNS RP (England) Year 4 (n=325 men, 400 women); 6: NDNS RP (England) Year 5 (n=60 men, 95 women); 7: England 2014 (n=298 men, 391 women); 8: England 2018/19 (n=286 men, 310 women).
A break has been added to the vertical axis between 0 and 5 g/day.
The population target maximum for salt intake is 5 g/day for women and 7 g/day in men and these are indicated by dashed red and blue lines, respectively.
The grey shaded regions indicate the 95% confidence intervals for the regression lines.

5.2 Step-change analysis results

There was a statistically significant (p=0.01) downward step-change in estimated daily salt intake between 2005/06 and 2008/09 for adults aged 19 to 64 years (geometric means 8.1 and 7.5 g/day, respectively) but no other significant step changes between the neighbouring survey groups between 2008/09 to 2018/19.

5.3 Trend analysis results 2008/09 and 2018/19

Because of the step change identified between 2005/06 and 2008/09, the trend analysis was repeated excluding 2005/06 to test for linear change since 2008/09.

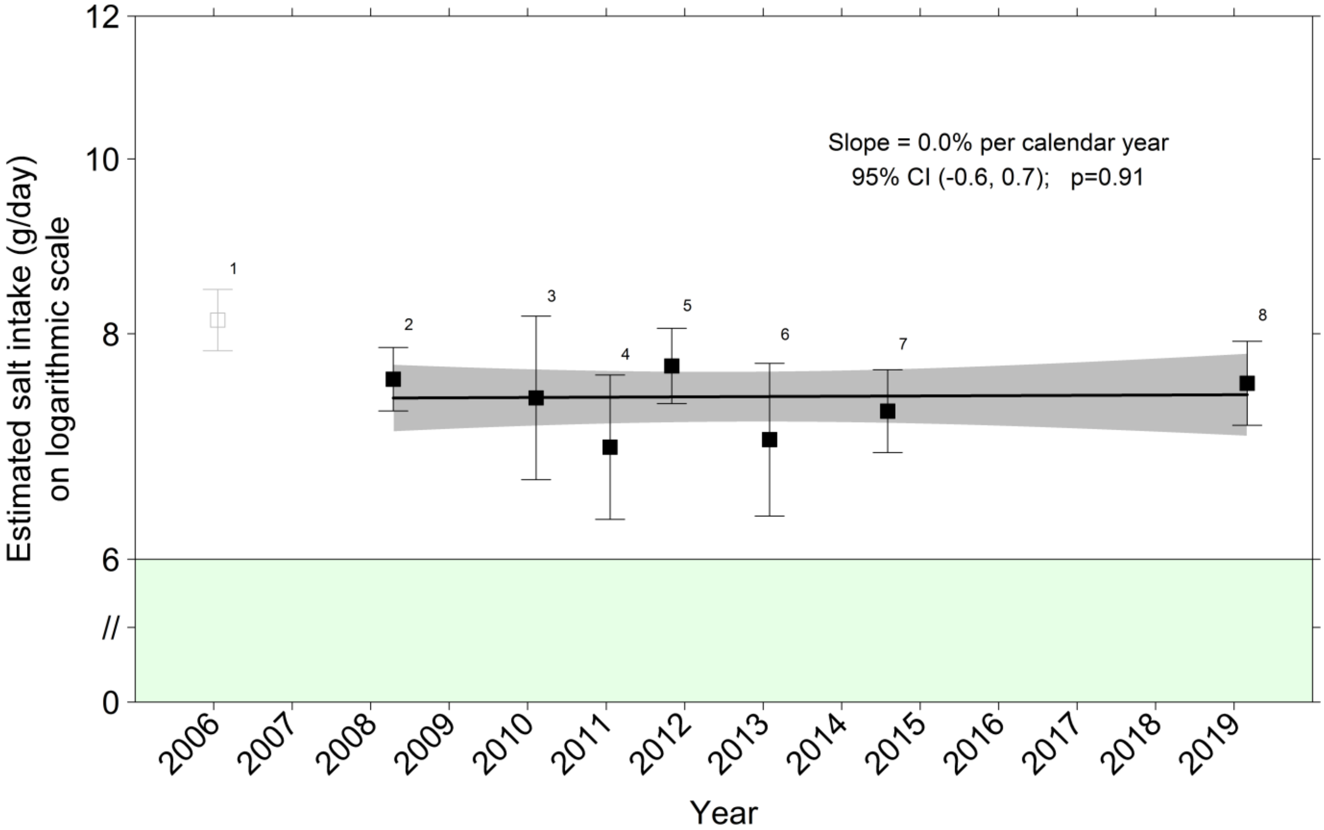
In table 5C the average percentage changes for adults aged 19 to 64 years and for men and women separately are provided. Survey geometric means and trend lines are plotted in figure 5.3 for all participants and figure 5.4 for men and women separately along with the population target maximum intake for women (5 g/day) and for men (7 g/day).[8]

The trend analysis between 2008/09 and 2018/19 indicated no statistically significant linear change in estimated daily salt intake over time.

Table 5C. Trend analysis results showing average percentage change in estimated daily salt intake in England between 2008/09 and 2018/19

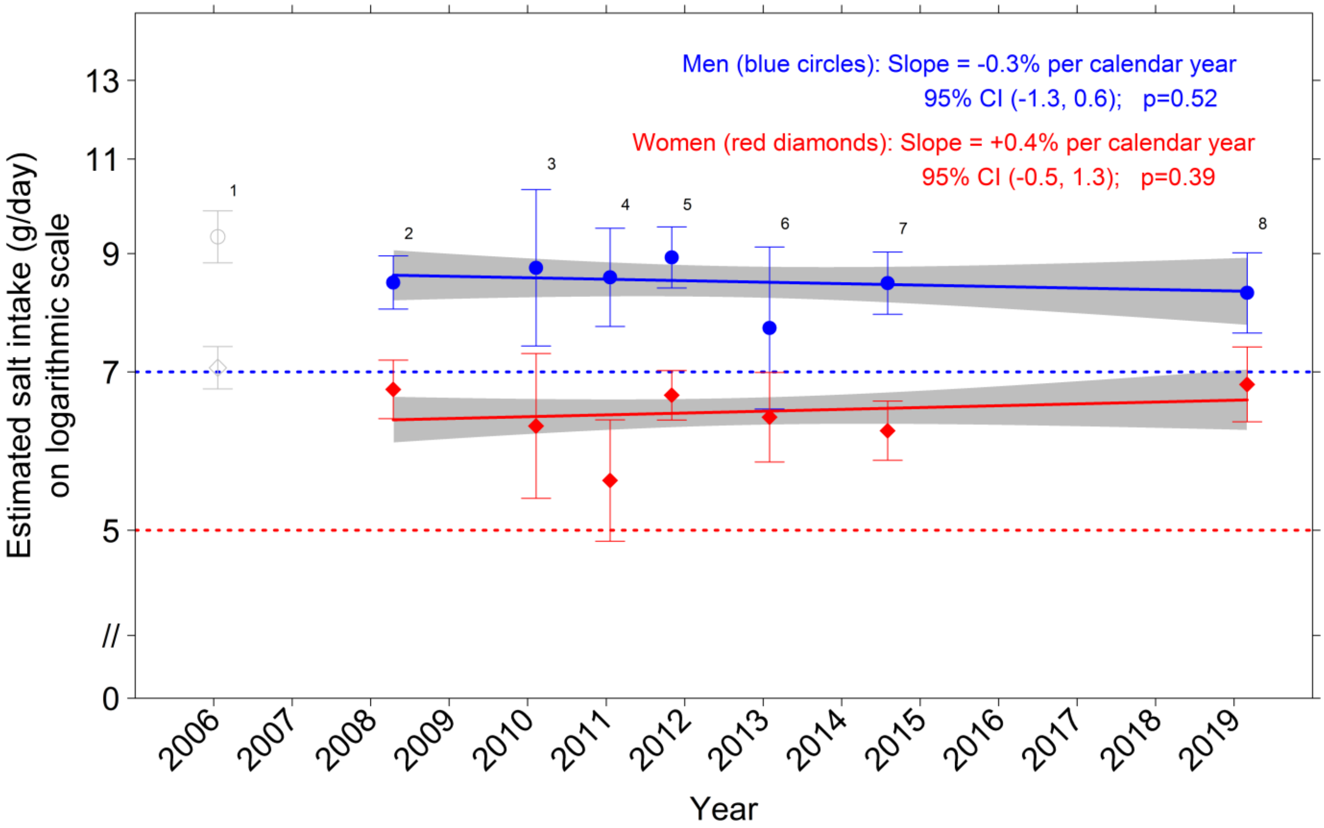
	Average yearly percentage change in estimated salt intake (95% CI)	Average 13-year percentage change in estimated salt intake (95% CI)
All participants	0.0 (-0.6, 0.7)	0.4 (-6.2, 7.6)
Men	-0.3 (-1.3, 0.6)	-3.3 (-12.9, 7.3)
Women	0.4 (-0.5, 1.3)	4.3 (-5.2, 14.8)

Figure 5.3. Trend in estimated salt intake (g/day) for adults aged 19 to 64 years in England between 2008/09 and 2018/19 (geometric means with 95% confidence intervals)



Numbers on chart indicate survey group: 1: England 2005/06 (n=445); 2: UK 2008 (England) and NDNS RP (England) Year 1 (n=688); 3: NDNS RP (England) Year 2 (n=109); 4: NDNS RP (England) Year 3 (n=109); 5: England 2011 and NDNS RP (England) Year 4 (n=725); 6: NDNS RP (England) Year 5 (n=155); 7: England 2014 (n=689); 8: England 2018/19 (n=596).
A break has been added to the vertical axis between 0 and 6 g/day.
The population target maximum for salt intake is 6 g/day and is indicated in green.
The grey shaded region indicates the 95% confidence interval for the regression line.

Figure 5.4. Trend in estimated salt intake (g/day) for men and women aged 19 to 64 years in England between 2008/09 and 2018/19 (geometric means with 95% confidence intervals)



Numbers on chart indicate survey group: 1: England 2005/06 (n=187 men, 258 women); 2: UK 2008 (England) and NDNS RP (England) Year 1 (n=301 men, 387 women); 3: NDNS RP (England) Year 2 (n=50 men, 59 women); 4: NDNS RP (England) Year 3 (n=56 men, 53 women); 5: England 2011 and NDNS RP (England) Year 4 (n=325 men, 400 women); 6: NDNS RP (England) Year 5 (n=60 men, 95 women); 7: England 2014 (n=298 men, 391 women); 8: England 2018/19 (n=286 men, 310 women).

A break has been added to the vertical axis between 0 and 5 g/day.

The population target maximum for salt intake is 5 g/day for women and 7 g/day in men and these are indicated by dashed red and blue lines, respectively.

The grey shaded regions indicate the 95% confidence intervals for the regression lines.

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