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Socio-economic inequality in salt intake in Britain 10 years after a national salt reduction programme.

Chen Ji, PhD, Research Fellow and **Francesco P Cappuccio***, FRCP, DSc, Professor of Cardiovascular Medicine & Epidemiology

University of Warwick, WHO Collaborating Centre for Nutrition, Warwick Medical School, Division of Mental Health & Wellbeing, Gibbet Hill Road, Coventry, CV4 7AL

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***Correspondence to:**

Prof F P Cappuccio

University of Warwick, WHO Collaborating Centre

Warwick Medical School, Division of Mental Health & Wellbeing

Gibbet Hill, Coventry CV4 7AL, UK

f.p.cappuccio@warwick.ac.uk

ABSTRACT

Background. In the 2000-2001 British National Diet and Nutrition Survey (NDNS) there were significant socio-economic inequalities in the distribution of salt intake, independent of the south-north gradient. Since then the UK has implemented a national salt reduction programme. The impact of such a programme on social inequalities, however, remains unknown.

Objectives. To examine the spatial and socio-economic variations in salt intake in the 2008-2011 British NDNS and to compare them with those before the programme.

Design. Cross-sectional survey.

Setting. Great Britain.

Participants. 1,027 white males and females, aged 19 to 64 years, from the British NDNS 2008-11.

Primary outcome. Participants' dietary sodium intake measured with a 4-day food diary. Bayesian geo-additive models were used to assess the spatial and socio-economic patterns of sodium intake while accounting for socio-demographic, anthropometric and behavioural confounders.

Results: Dietary sodium intake varied significantly across socio-economic groups, even when adjusting for geographical variations. Higher dietary sodium intake was found in people with the lowest educational attainment (coeff: 0.252 [90% credible intervals 0.003, 0.486]) and in low levels of occupation (coeff: 0.109 [-0.069, 0.288]). Those with no qualification had, on average, a 5.7% [0.1, 11.1] higher dietary sodium intake than the reference group. Compared to 2000-01 the gradient of higher dietary sodium intake from south to north still remained but it was no longer significant when adjusted for socio-economic status and other confounders. Estimated dietary sodium consumption from food sources (not accounting for discretionary sources) was reduced by 366 mg of sodium (~0.9 g of salt) per day during the 10-year period, likely the effect of national salt reduction initiatives. However, the social inequalities remained.

Conclusions: Understanding the socio-economic pattern of salt intake is crucial to reduce inequalities. Efforts are needed to minimise the gap between socio-economic groups for an equitable delivery of cardiovascular prevention.

ARTICLE SUMMARY

Article focus

- To examine the spatial and socio-economic variations in salt intake in the 2008-2011 British National Diet and Nutrition Survey and to compare them with those before the implementation of a national programme of population-wide dietary salt reduction.

Key messages

- In 2008-11 people in Scotland still tend to eat more salt than those in England and Wales, as shown in 2000-2001.
- After allowing for geographic differences, dietary salt intake was higher in low socio-economic groups as those in manual occupations or those with lower educational attainment.
- Social inequalities in salt intake have not seen a reduction following the national salt reduction programme and still explain more than 5% of salt intake between more and less affluent groups.
- Care must be taken to ensure that socio-economic gaps in salt intake are not inadvertently widened by monitoring the differential policy impact of salt reduction programmes**.**

Strength and limitations of this study

- The National Diet and Nutrition Survey is a rolling programme of screening of a nationally representative sample of the British population regarding diet, nutrient intake and nutritional status.
- This analysis is the first evaluation of the effect of a national programme of salt reduction on social inequalities.
- The Bayesian approach allows for spatial variations as well as the contribution of known and unknown confounders to be determined.
- Estimates of dietary intake are reinforced by the parallel update of food composition tables on salt content.
- Dietary salt intake was assessed by 3- or 4-day food diaries. This is at variance with the 2000-2001 survey when dietary salt intake was assessed with 7-day dietary records.
- Only salt coming from food was assessed, with no inclusion of discretionary salt deriving from that added to food at the table, during the cooking process and in restaurants and other food outlets.
- The definitions of SES were based on occupation and educational attainment.
- Results are based on the white respondents of the survey, since the representation of ethnic minority groups is still insufficient for independent analysis.
- Limitations are also due to the relatively small number of spatial units and to regional classifications.
- Residual confounding cannot be ruled out completely

BACKGROUND

High blood pressure (BP) is the most common, yet preventable, cause of morbidity, disability and death worldwide, responsible for more than half the deaths from coronary heart disease (CHD), stroke and cardiovascular disease (CVD)[1]. The risk of CVD is now becoming more prevalent in low-and-middle income countries[2] and, within countries, is more prevalent in socially disadvantaged groups[3]. A reduction in high BP with antihypertensive medications significantly reduces BP and CVD[4]. However, the majority of events in the population occur in the range of BP not qualifying for drug therapy. A population approach to achieve small BP reductions across the whole range of BP levels would therefore avert the majority of CVD events[5]. Finally, in low-and-middle-income countries the implementation of health care programmes of detection, management and control of hypertension with drugs are still haphazard due to high costs and lack of health care infrastructures[6;7], making non-pharmacological public health programmes of primary prevention a cost-effective priority[8;9].

Evidence from a variety of sources shows a consistent relationship between salt intake and BP, so that a moderate reduction in salt intake reduces BP in a dose-dependent manner, in men and women, young and old, all ethnic groups and at any level of BP[10]. Furthermore, there is evidence to suggest that these effects on BP could lead to a significant reduction in cardiovascular events, and crucially in strokes[11;12]. Several approaches can be taken to reduce population salt intake[10] and national and international organizations have now developed policies and started population programmes aiming at a reduction in population salt intake[13], a cost-effective prevention policy[14;15] with rapidly occurring health benefits[16;17].

Dietary salt, primarily sodium chloride, is commonly used for food preservation and seasoning. In most westernised countries, like the UK, approximately 75% of salt consumed is hidden in processed and restaurant foods whereas only about 15% comes from discretionary use (added at the table or in cooking by the consumer or food handler)[18].

Driven by this evidence the UK Food Standards Agency (FSA) initiated a salt reduction program in 2003, aiming to reduce the salt intake to 6 g/day in the UK population[19]. Later, the FSA and the Department of Health worked together with the food industry to reduce the sodium content in processed foods by setting voluntary salt reduction targets, run a public campaign to raise customer awareness and developed a food labelling scheme[20]. After 10 years, the salt intake in the UK has decreased by 1.4 g per day, a 15% reduction, from 9.5 to 8.1 g per day[21]. This reduction has been associated with a BP reduction of 3.0/1.4 mmHg and a parallel decline in CHD and stroke mortality[21]. The sodium content of processed food in supermarkets has also been reduced by 20-30%[22], particularly in packaged bread, the biggest contributor of salt intake in the British diet[23].

CVD is more prevalent in socio economically deprived populations and groups within populations. Low socio-economic status is associated with hypertension and high risks of stroke, CHD and renal failure[24]. These groups are more likely to depend on cheaper unhealthy processed food diets, high in salt[25]. The Marmot Review[26] affirmed social inequalities as important determinants of ill-health in the British population, highlighting the social gradient in health inequalities, whereby people of poorer background not only die sooner but spend more of their lives with disabilities. Health inequalities arise from a complex interaction of many factors, one of which is bad diet and nutrition. Health inequalities are preventable through government policies aimed at the population as a whole[26]. Population-based strategies for prevention tend to reduce health inequalities, as they are usually 'structural'[27]. Furthermore, the risk of hypertension associated with low parental social status can be modified by an improvement in social status later in life[28], suggesting targets for public health policies and political interventions. However, effective polices are less likely to be implemented in low-and-income countries, as it is the case for salt reduction in the European regions[29]. In a previous analysis using the National Diet and Nutrition Survey (NDNS) 2000-01, we identified significant spatial and socio-economic patterns of salt intake (measured by dietary sodium and urinary sodium) in Britain[30]. Salt intake was found to be high in Scotland and in lower socio-economic groups. As the UK program has successfully reduced the population salt intake, it is yet unknown whether this national programme has made any change in this inequality. Thus, this paper aims to examine the spatial and socio-economic patterns of salt intake using recently released UK NDNS data (2008-11), and compare the possible change of these patterns before and after the implementation of the UK salt reduction programme.

Data and Methods

This analysis was conducted using data from the 2008-11 British National Diet and Nutrition Survey (NDNS). This survey is part of a national programme set up in 1992 to provide a cross-sectional and nationally representative sample of the British population regarding diet, nutrient intake and nutritional status. Details of the fieldwork and the survey are described elsewhere[31]. In 2008, it changed to a rolling programme to better capture trends and to quickly meet political needs. One thousand to 1,500 people aged 1.5 to 94 years are recruited every year as a representative sample of the general population in the UK (including England, Wales, Scotland and Northern Ireland). Participants are classified into three age groups: 1.5-18 years, 19-64 years and 65 years and over. The fieldwork for the latest survey was carried out throughout 2008-11 to account for any possible seasonal variations in dietary intake. At household level, about 26% of the 9,990 issued household addresses were selected for the survey in three years. At individual level, 3,073 individuals participated in the interview by completing a series of questionnaires and measurements, including a 3- or 4-day food diary, a socio-demographic background interview, height and weight measurements, smoking and drinking assessments by self-completed questionnaires, and an assessment of physical activity by self-completed questionnaires or ActiGraph. Seventy five per cent (unweighted for age, N=2,318) of the participants were then visited by a nurse. This procedure included physical and BP measurements, a blood sample and a 24h urine collection, and collection of data on prescribed medicines. At this stage, 53% (unweighted for age, N=1,614) of the interviewed participants provided 24h urine sample (data not released to date). Of the total participants, 39% (N=1,186) were adults (19-64 years). White respondents accounted for 90% (N=1,069) of the adult population. Ethnic minority groups were excluded since estimation on few participants may not be representative of their ethnic group, particularly when compared by region. Finally participants from Northern Ireland were also excluded due to small numbers (n=42), leaving a total sample size of 1,027.

Height and weight were measured at the nearest 0.1 cm and 0.1 kg, respectively, to calculate body mass index (BMI=weight/height (kg/m^2)). BP measurements were taken three times in a sitting position. The average of the second and third reading was used as the participant's BP level. Socio-economic status (SES) was measured by two indicators, educational attainment and occupation. Educational attainment was based on the information of the highest qualification achieved. Some participants obtained foreign qualifications or were still in full-time education. Hence, a missing value was assigned to those participants. Occupation was determined by the socio-economic classification (SEC) of the household reference person (HRP). Unlike the previous cross-sectional programme (based on The Registrar-General's Social Classes), the rolling programme defines the SEC by the National Statistics Socio-economic classification (NS-SEC), which is developed from the Standard Occupational Classification 2010 (SOC2010). Details of the definitions of the classification can be found in the NDNS year 3 report[32]. The NS-SEC grouped the participants into 8 occupational classes: 1) higher managerial, administrative and professional; 2) Lower managerial, administrative and professional; 3) Intermediate; 4) Small employers and own account workers; 5) Lower supervisory and technical; 6) Semi-routine; 7) Routine; and 8) Never worked and long-term unemployed. The SES information was simplified into 3-class version[33]: 1) Higher managerial, administrative and professional (containing level 1-2); 2) Intermediate (level 3-4); 3) Routine and manual (5-7). There were only 18 participants in the “Never worked and long-term unemployed” category (level 8). Hence, they were coded as missing values. Meanwhile, some participants classified as full-time students or other occupations not stated or inadequately described were also coded as missing values. Marital status included 5 categories: 1) single, 2) married and living with husband or wife, 3) married and separated, 4) divorced, 5) widowed. With the information of whether they were living with a partner, the marital status used in this analysis was coded as either living alone or living with partner. Smoking habit was derived from questions concerning current and previous smoking history. Based on their smoking history, the NDNS participants were recorded as current, former or non-smoker. The food diary provided each participant’s nutrient and energy intakes in weekdays and weekends. Sodium and energy intakes and alcohol consumption were based on the average of the 4-day dietary data. However, salt used in cooking and on the table (discretionary salt) was not measured.

Geographical boundaries

The NDNS rolling programme was conducted across the UK, including England, Scotland, Wales and Northern Ireland[34]. The regional classification of England used in the rolling programme was different to the classification used in previous surveys, particularly in the north and south east part of England, which was mainly due to the use of Government Office Regions (GORs) 2011. Details can be found on the website of the Office for National Statistics[35]. As the Bayesian models are unable to make estimation over disconnected regions (i.e. Northern Ireland and the rest of Great Britain), data collected from Northern

Ireland were excluded from this study. Therefore, the analysis was limited to mainland Britain, and only boundary data of England, Scotland and Wales were collected from UK Boarders.

Statistical Methods

Kruskal-Wallis test was used to compare the regional difference of dietary sodium intake. Bayesian geo-additive models were employed to analyse the spatial and socioeconomic patterns of sodium intake while accounting for the linear or nonlinear effects of a range of important covariates, as detailed elsewhere[30]. Four models were built and assessed. One level of each categorical factor was set as the reference level for effect assessment. Cube root transformation was used to normalise the dietary sodium intake. This was identical to the transformation used in our previous analysis[30]. Deviance information criterion (DIC) was used for model selection. The model with the smallest DIC value was preferred (**appendix 1**). The descriptive analysis and tests were conducted using SPSS v21 (IBM Corp. Armonk, NY, USA). Model estimations were conducted in BayesX Version 2.1 (07.05.2012)[36]. The statistical significance level was set as α=0.05 in the descriptive analysis and α=0.1 in the models. The West Midlands BREC (158-01-2012) approved the analysis.

RESULTS

One thousand and twenty seven white participants were included in the analysis. The age and sex adjusted characteristics of the study population are summarised in **table 1**. The mean age was 43.3 (95% confidence interval 42.5 to 44.0) years and women accounted for 56.4% (N=579) of the sample. 27.1% of the participants had a higher educational attainment, 31.1% an A level, below degree or equivalent educational attainment, and 25.5% a GCSE or equivalent educational attainment. Participants in higher social-economic groups accounted for 45.9% of the sample.

Dietary sodium

The median sodium intake was 2,245 (IQR=1,092) mg/day, which approximated to 5.6g of salt/day (100mg sodium = 0.25g salt). The median energy intake was 1,799 (IQR=761) kcal/day. **Figure 1** shows the observatory map of sodium intake by region. Sodium intake was highest in Scotland, followed by the West Midlands. The regional differences, however, were not statistically significant (p=0.145) (**table 2**).

The DIC results of the models were presented in **appendix 1**. Model 3 with linear assumption of the covariates performed the best in terms of the DIC value. Hence, the results of Model 3 were presented in **table 3**. Once adjusted for all confounders in the model, dietary sodium intake significantly decreased with age and men had higher dietary sodium intake than women. As expected, dietary sodium intake was positively associated with body mass as a result of its association with energy intake. Participants at the lowest end of educational attainment (no qualification) had significantly higher dietary sodium intake that the reference group (higher education at degree level) (5.7% [0.1, 11.1]; **appendix 2**). To avoid the effect of residual confounding, a set of models with 5-category factors was also examined. No substantial change, particularly in terms of the statistical significance, was detected between the two approaches (results not shown). A similar trend (though not statistically significant) was observed between dietary sodium intake and occupation.

Comparison with the 2000-01 NDNS

Compared with the analysis of the NDNS 2000-01[30], whilst the spatial differences in dietary sodium intake in NDNS 2008-11 still followed the pattern of increasing levels from south to north (with Scotland showing the highest), the results were no longer statistically significant (**figure 1 and table 2**). Between the two surveys (almost 10 years apart) there was an average reduction in dietary sodium intake of 366mg per day (or 0.9g of salt per day). Crucially, the socio-economic gradient remained (**figure 2**). If anything, the proportional gap appeared to widen (from 3.5% [0.1, 7.2] to 5.7% [0.1, 11.1]) between those with no qualification and the reference group (higher education at degree level)(**appendix 2**).

DISCUSSION

Our analysis confirms a socio-economic gradient in dietary salt intake in the British Isles in 2008-11 independent of a geographic gradient. In addition it shows for the first time that after 10 years of a national programme of population reduction in salt intake, social inequalities in salt consumption have remained. This study extends our original approach of analysing spatial variations of salt intake to establish the contribution of socio-economic variations and other confounders after 10 years of a population-based programme of salt reduction, thus providing a unique opportunity to evaluate effects on inequalities.

Strengths and limitations

The study has strengths. The National Diet and Nutrition Survey is a rolling programme of screening of a nationally representative sample of the British population regarding diet, nutrient intake and nutritional status. This analysis is the first evaluation of the effect of a national programme of salt reduction on social inequalities. The Bayesian approach allows us to determine spatial variations as well as the contribution of known and unknown confounders. Finally, estimates of dietary intake are reinforced by the fact that food composition tables on salt content have been updated recently.

The study has limitations. Dietary salt intake was assessed by 3- or 4-day food diaries. This is at variance with the 2000-2001 survey when dietary salt intake was assessed with 7-day dietary records[30]. Notwithstanding the general comparability of group estimates using the two methods[37;38], in this round only salt coming from food was assessed, with no inclusion of discretionary salt deriving from that added to food at the table, during the cooking process and in restaurants and other food outlets. Discretionary salt intake may account for approximately 25% of the total salt consumption[18], and additional socio-economic inequalities in salt consumption may well depend on further variations in discretionary use. Total salt intake is best measured by 24h urinary sodium excretion[39;40]. In the 2000-2001 analysis both spatial and socio-economic patterns were comparable with dietary and total salt estimates[30]. The definitions of SES were based on occupation and educational attainment. Whilst limited, these definitions are comparable to those used in 2000-2001[30]. Our results are based on white respondents, since the representation of ethnic minority groups was still insufficient for an independent analysis. The generalizability of the findings is therefore limited to whites. Limitations are also the relatively small number of spatial units and regional classifications[30]. The possibility of residual confounding cannot be ruled out completely.

Context

The UK initiated a nationwide salt reduction programme in 2003/4 based on several public awareness campaigns, setting progressing targets on the salt content of processed food led by the Food Standard Agency, a voluntary agreement with the food industry to reformulate bread and processed foods and a rolling programme of repeated surveys to monitor the salt intake of the population[10] and the salt content of some food category[23]. The programme has been successful and resulted in a 1.4g per day (15%) reduction in population salt consumption by 2011, as measured by 24h urinary sodium excretion (from 9.5g per day in 2003 to 8.1g per day in 2011)[21]. During the same period of time population BP fell by 3.0/1.4 mmHg (2.7/1.1 mmHg in those not on treatment for hypertension), and both stroke and IHD mortality by 36% decreased by 36%[21]. The average salt level in bread fell from 1.23g per 100g in 2001 to 0.98g per 100g in 2011, and the number of products meeting the 2012 targets increased from 28% in 2001 to 71% in 2011[23]. Our study indicates a 0.9g per day reduction in population dietary salt intake between surveys which should be interpreted as primarily deriving from food reformulation rather than by behavioural modifications in the use of discretionary salt at the table and in cooking.

Implications for policy

The diet of socio-economically disadvantaged groups is made of low-quality, salt-dense, high-fat, high-calorie unhealthy cheap foods. Behavioural approach to healthy eating is unlikely to bring about the changes necessary to halt and revert the non-communicable diseases epidemic and they may widen inequalities[10;27;41]. SES inequalities in dietary access and consumption of healthy foods are widely documented[26], both within countries[3] and between countries[29], and for salt intake are detectable in children[42] as well as adults[30]. Australian children from a low SES have on average 9% greater intake of salt from food sources compared to those from a high SES[42]. In our study these differences are estimated to be between 5% and 6%.

The findings of a sustained SES gradient in population dietary salt intake from 2000-2001 to 2008-11 is disappointing as one would have expected a larger reduction in lower SES following a population-wide approach[27]. There are multiple interpretations of these findings. Firstly, our results do not indicate that the total salt consumption is still higher in low SES as we do not have measures of 24h urinary sodium excretion in the 2008-11 survey. However, in the 2000-2001 both measures (dietary sodium and 24h urinary sodium) were used and the results were consistent[30]. Secondly, to counterbalance the higher dietary salt intake in low SES, the same groups should have reduced discretionary salt substantially following public awareness campaigns, an effect not anticipated[27] and not reported as yet in the literature. Thirdly, the inequalities we detect for dietary salt intake could be even greater if we assumed that the consumption of junk food from unregulated street retailers is more common in people of low SES. Indeed, recent results from the analysis of data for take-home food and beverage purchases from British households in 2010 indicates that shopping baskets of higher SES groups are healthier (proportionally more purchasing of fiber, protein and total sugars and less sodium) than those of lower SES groups[25]. Fourthly, it is possible that the reformulation of food items (beyond bread) has covered disproportionately food items not predominantly purchased by low SES groups. A more detailed monitoring of household food purchasing in relation to targeted reformulation and improved access by acting on pricing should be included in surveillance methods to reveal potential targets to reduce social inequalities in salt intake.

Conclusions

Understanding the socio-economic pattern of salt intake is crucial to reduce inequalities. Efforts are needed to minimise the gap between socio-economic groups for an equitable delivery of cardiovascular prevention.

Contributors. FPC developed the idea, obtained funding, supervised the analysis and drafted the manuscript. CJ carried out the statistical analysis and prepared the draft methods and results. Both made significant contributions to the draft manuscript. FPC acts as guarantor.

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Competing interests. FPC is unpaid member of CASH, WASH, UK National Forum, UK Public Health NACD, unpaid technical advisor to NICE, the World Health Organization and the Pan-American Health Organization and Trustee of the Student Heart Health charity.

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Table 1: Age and sex adjusted characteristics of the population of the National Diet and Nutrition Survey 2008-2011.

Variable	Total (N=1,027)
Age (year)	43.3 (42.5, 44.0)
Sex (%)	
Male	43.6
Female	56.4
Weight (kg)	78.9 (77.9, 79.8)
Height (cm)	169.5 (169.1, 169.9)
BMI (kg/m^2)	27.4 (27.0, 27.7)
Smoking habit (%)	
Non-smoker	36.0
Former smoker	36.6
Current smoker	27.4
Marital status (%)	
Living with partner	63.8
Living alone	36.2
Education attainment (%)	
Higher education	27.1
Below degree, A level or equivalent	31.1
GCSE or equivalent	25.5
No qualification	16.2
Occupation (%)	
Professional, managerial, administrative	45.9
Intermediate	20.0
Routine and manual	34.1
Sodium intake (mg/day)*	2,245 (1,092)
Energy intake (kcal/day)*	1,799 (761)
Alcohol consumption (g/day)*	6.0 (23.0)
Region (%)	
North East	4.2
North West	13.0
Yorkshire and the Humber	8.2
East Midlands	10.7
West Midlands	11.0
East of England	9.7
London	6.3
South East	15.6
South West	7.9
Wales	5.9
Scotland	7.5

Note: Results are mean (95% confidence intervals) and percentage, unless stated; BMI, body mass index; GCSE, General Certificate of Secondary Education;
*: Median with Interquartile Range.

Table 2: Dietary sodium intake (without discretionary salt consumption) by region in the 2008-2011 National Diet and Nutrition Survey sample of white participants.

Region	**Sodium intake (mg/day)** Mean (SD)	**Salt equivalent (g/day)** Mean (SD)
North East	2,106 (1,087)	5.26 (2.72)
North West	2,228 (1,104)	5.57 (2.76)
Yorkshire and the Humber	2,186 (1,193)	5.47 (2.98)
East Midlands	2,244 (1,176)	5.61 (2.94)
West Midlands	2,343 (1,167)	5.86 (2.92)
East of England	2,167 (1,103)	5.42 (2.76)
London	2,170 (1,054)	5.43 (2.64)
South East	2,179 (953)	5.45 (2.38)
South West	2,251 (987)	5.63 (2.47)
Wales	2,027 (1,073)	5.07 (2.68)
Scotland	2,447 (1,046)	6.12 (2.62)

Table 3: Fixed effect of dietary sodium intake in the 2008-2011 National Diet and Nutrition Survey sample of white participants.

Factor	Mean (90% credible interval)
Age (year)	*-0.012 (-0.018, -0.006)*
Female	0
Male	*0.342 (0.176, 0.499)*
BMI (kg/m2)	*0.018 (0.003, 0.032)*
Smoking habit	
Non	0
Former	0.107 (-0.048, 0.264)
Current	-0.044 (-0.241, 0.152)
Marital status	
Living together	0
Living alone	0.005 (-0.139, 0.158)
Education attainment	
Higher Education (degree level)	0
A level or equivalent	*0.191 (0.009, 0.380)*
GCSE or equivalent	0.159 (-0.060, 0.367)
No qualification	*0.252 (0.003, 0.486)*
Occupation	
Professional, managerial, administrative	0
Intermediate	-0.036 (-0.234, 0.158)
Routine and manual	0.109 (-0.069, 0.288)
Alcohol consumption (g/day)	*-0.009 (-0.012, -0.006)*
Energy intake (kcal/day)	*0.0019 (0.0018, 0.002)*

Note: reference level was set as 0 in each categorical variable.
The effect is significant if the entire interval does not contain 0 and it is printed in *italics*.

Figure 1. Estimated posterior mean residual spatial regional effects of dietary sodium intake. The colour band represents the range of regional effect. Shades in red/green correspond to high/low level of dietary sodium consumption.

Figure 2: The effect of education attainment (and 90% credible intervals) on dietary sodium intake in Britain in 2000-01* (top) and 2008-11 (bottom).

Note: Higher education (degree level) was used as the reference level. The effect of each educational attainment was derived by assuming a 2,500 mg dietary sodium intake per day (approximately 6.26 g/day in salt, not including discretionary salt intake) for an adult holding a degree (reference). The effect is considered significant if the entire credible interval does not include 0.

*: Although the Bayesian geo-additive models were used using the same set of factors with the same model setting, "social class" was defined using a different classification in 2000-01. In addition, the dietary sodium, energy and alcohol intakes were measured based on a 7-day dietary record in 2000-01 and on 4-day food diaries in 2008-11.

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Figure 1

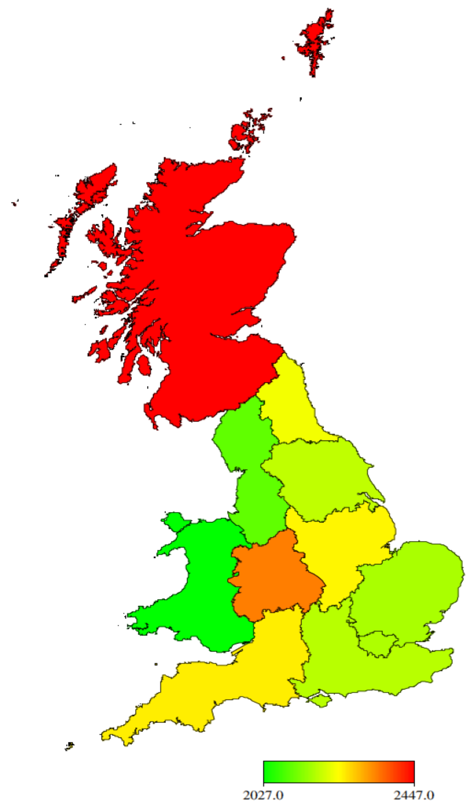

Figure 2

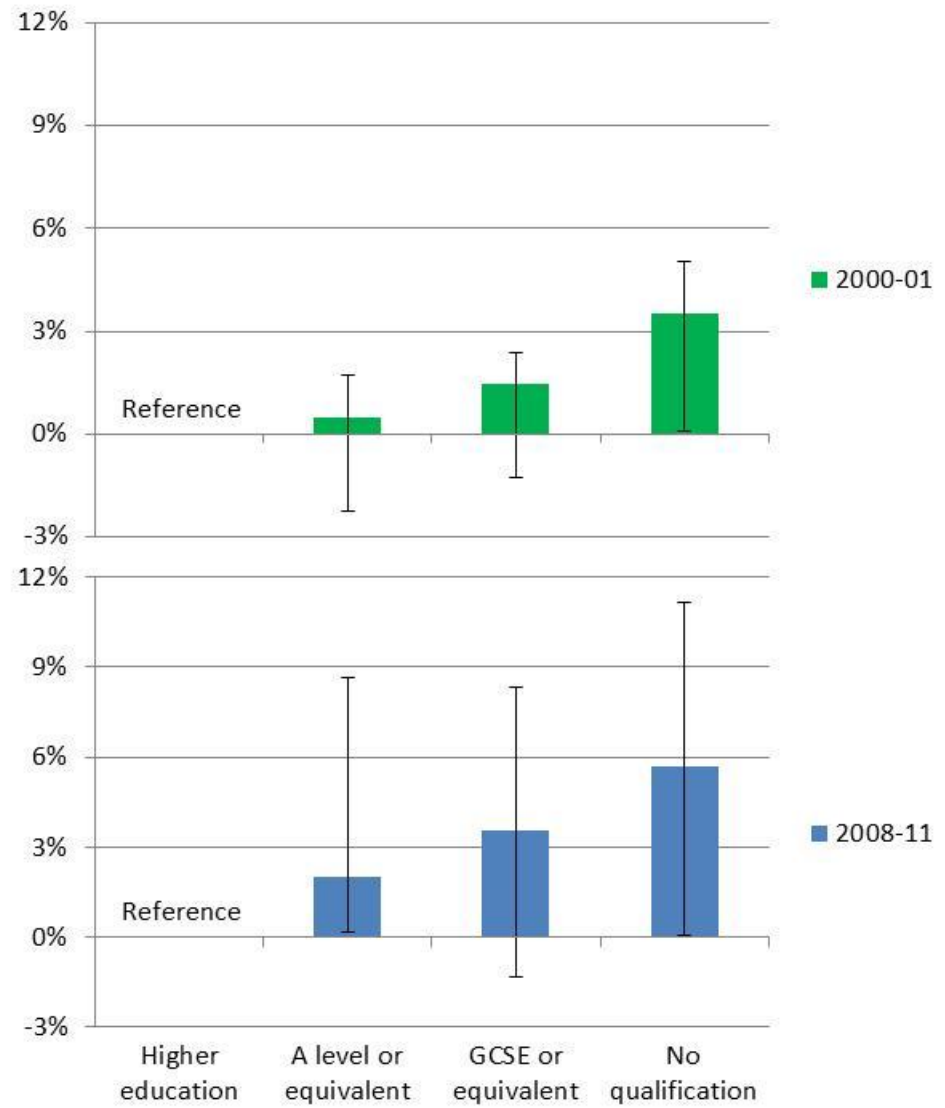
12%
9%
6%
3%
0%
-3%
Reference
2000-01
12%
9%
6%
3%
0%
-3%
Reference
2008-11
Higher education
A level or equivalent
GCSE or equivalent
No qualification

Table Appendix 1: Model comparison.

	Model 1	Model 2	Model 3	Model 4
Deviance	1016.58	938.9	586.5	574.8
pD	8.1	12.4	20.5	32.7
DIC	1032.8	963.8	627.6	640.1

Note: Model 1= Region only; Model 2 = Model 1 + Age + Sex + Body Mass Index + Energy intake; Model 3 = Model 2 + Smoking habit + Education + Socio-economic status + Marital status + Alcohol consumption; Model 4 = Model 3 with nonlinear assumption on all continuous variables (Age, BMI, Energy intake, Alcohol consumption).

Table Appendix 2. Estimated coefficients of each level of education attainment in 2000-01 and 2008-11 using the assumption of 2,500 mg/day intake of dietary sodium.

	Mean % change	90% Credible interval	
	2000-01		
Higher education	Reference		
A level or equivalent	0.5%	-2.3%	3.3%
GCSE or equivalent	1.4%	-1.3%	4.5%
No qualification	3.5%	0.1%	7.2%
	2008-11		
Higher education	Reference		
A level or equivalent	2.0%	0.2%	8.6%
GCSE or equivalent	3.6%	-1.3%	8.3%
No qualification	5.7%	0.1%	11.1%

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Socio-economic inequality in salt intake in Britain 10 years after a national salt reduction programme.

Chen Ji, PhD, Research Fellow and **Francesco P Cappuccio***, FRCP, DSc, Professor of Cardiovascular Medicine & Epidemiology

University of Warwick, WHO Collaborating Centre for Nutrition, Warwick Medical School, Division of Mental Health & Wellbeing, Gibbet Hill Road, Coventry, CV4 7AL

Key words: Salt intake; Salt reduction policy; Social inequalities; Socio-economic status

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Appendix: Tables 1-2

***Correspondence to:**

Prof F P Cappuccio

University of Warwick, WHO Collaborating Centre

Warwick Medical School, Division of Mental Health & Wellbeing

Gibbet Hill, Coventry CV4 7AL, UK

f.p.cappuccio@warwick.ac.uk

ABSTRACT

Objectives. The impact of the national salt reduction programme in the UK on social inequalities is unknown. We examined spatial and socio-economic variations in salt intake in the 2008-2011 British NDNS and compared them with those before the programme in 2000-1.

Setting. Cross-sectional survey in Great Britain.

Participants. 1,027 white males and females, aged 19 to 64 years.

Primary outcome measures. Participants' dietary sodium intake measured with a 4-day food diary. Bayesian geo-additive models used to assess spatial and socio-economic patterns of sodium intake accounting for socio-demographic, anthropometric and behavioural confounders.

Results: Dietary sodium intake varied significantly across socio-economic groups, even when adjusting for geographical variations. There was higher dietary sodium intake in people with the lowest educational attainment (coeff: 0.252 [90% credible intervals 0.003, 0.486]) and in low levels of occupation (coeff: 0.109 [-0.069, 0.288]). Those with no qualification had, on average, a 5.7% [0.1%, 11.1%] higher dietary sodium intake than the reference group. Compared to 2000-01 the gradient of dietary sodium intake from south to north was attenuated after adjustments for confounders. Estimated dietary sodium consumption from food sources (not accounting for discretionary sources) was reduced by 366 mg of sodium (~0.9 g of salt) per day during the 10-year period, likely the effect of national salt reduction initiatives.

Conclusions: Social inequalities in salt intake have not seen a reduction following the national salt reduction programme and still explain more than 5% of salt intake between more and less affluent groups. Understanding the socio-economic pattern of salt intake is crucial to reduce inequalities. Efforts are needed to minimise the gap between socio-economic groups for an equitable delivery of cardiovascular prevention.

ARTICLE SUMMARY

Article focus

- To examine the spatial and socio-economic variations in salt intake in the 2008-2011 British National Diet and Nutrition Survey and to compare them with those before the implementation of a national programme of population-wide dietary salt reduction.

Key messages

- In 2008-11 people in Scotland still tend to eat more salt than those in England and Wales, as shown in 2000-2001.
- After allowing for geographic differences, dietary salt intake was higher in those with lower educational attainment and showed a tendency for being high in those in manual occupations.
- Whilst there has been a reduction in salt intake overall, social inequalities in salt intake have not narrowed following the national salt reduction programme and still explain approximately 5% of salt intake difference between more and less affluent groups.
- Care must be taken to ensure that socio-economic gaps in salt intake are not inadvertently widened by monitoring the differential policy impact of salt reduction programmes.

Strength and limitations of this study

- The National Diet and Nutrition Survey is a rolling programme of screening of a nationally representative sample of the British population regarding diet, nutrient intake and nutritional status.
- This analysis is the first evaluation of the effect of a national programme of salt reduction on social inequalities.
- The Bayesian approach allows for spatial variations as well as the contribution of known and unknown confounders to be determined.
- Estimates of dietary intake are reinforced by the parallel update of food composition tables on salt content.
- Dietary salt intake was assessed by 3- or 4-day food diaries. This is at variance with the 2000-2001 survey when dietary salt intake was assessed with 7-day dietary records.
- Only salt coming from food was assessed, with no inclusion of discretionary salt deriving from that added to food at the table, during the cooking process and in restaurants and other food outlets.
- The definitions of SES were based on occupation and educational attainment.
- Results are based on the white respondents of the survey, since the representation of ethnic minority groups is still insufficient for independent analysis.
- Limitations are also due to the relatively small number of spatial units and to regional classifications.
- Residual confounding cannot be ruled out completely

BACKGROUND

High blood pressure (BP) is the most common, yet preventable, cause of morbidity, disability and death worldwide, responsible for more than half the deaths from coronary heart disease (CHD), stroke and cardiovascular disease (CVD)[1]. The risk of CVD is now becoming more prevalent in low-and-middle income countries[2] and, within countries, is more prevalent in socially disadvantaged groups[3]. A reduction in high BP with antihypertensive medications significantly reduces BP and CVD[4]. However, the majority of events in the population occur in the range of BP not qualifying for drug therapy[5]. A population approach to achieve small BP reductions across the whole range of BP levels would therefore avert the majority of CVD events[6]. Finally, in low-and-middle-income countries the implementation of health care programmes of detection, management and control of hypertension with drugs are still haphazard due to high costs and lack of health care infrastructures[7;8], making non-pharmacological public health programmes of primary prevention a cost-effective priority[9;10].

Evidence from a variety of sources shows a consistent relationship between salt intake and BP, so that a moderate reduction in salt intake reduces BP in a dose-dependent manner, in men and women, young and old, all ethnic groups and at any level of BP[11]. Furthermore, there is evidence to suggest that these effects on BP could lead to a significant reduction in cardiovascular events, and crucially in strokes[12;13]. Several approaches can be taken to reduce population salt intake[11] and national and international organizations have now developed policies and started population programmes aiming at a reduction in population salt intake[14], a cost-effective prevention policy[15;16] with rapidly occurring health benefits[17;18].

Dietary salt, primarily sodium chloride, is commonly used for food preservation and seasoning. In most westernised countries, like the UK, approximately 75% of salt consumed is hidden in processed and restaurant foods whereas only about 15% comes from discretionary use (added at the table or in cooking by the consumer or food handler)[19].

Driven by this evidence the UK Food Standards Agency (FSA) initiated a salt reduction program in 2003, aiming to reduce the salt intake to 6 g/day in the UK population[20]. Later, the FSA and the Department of Health worked together with the food industry to reduce the sodium content in processed foods by setting voluntary salt reduction targets, run a public campaign to raise customer awareness and developed a food labelling scheme[21]. After 10 years, the salt intake in the UK has decreased by 1.4 g per day, a 15% reduction, from 9.5 to 8.1 g per day[22]. This reduction has been associated with a BP reduction of 3.0/1.4 mmHg and a parallel decline in CHD and stroke mortality[22]. The sodium content of processed food in supermarkets has also been reduced by 20-30%[23], particularly in packaged bread, the biggest contributor of salt intake in the British diet[24].

Health inequalities are variations in health status across individuals in a population[25]. Health inequalities by socio-economic status are common. CVD is more prevalent in socio economically deprived populations and groups within populations. Low socio-economic status is associated with hypertension and high risks of stroke, CHD and renal failure[26]. These groups are more likely to depend on cheaper unhealthy processed food diets, high in salt[27]. The Marmot Review[28] affirmed social inequalities as important determinants of ill-health in the British population, highlighting the social gradient in health inequalities, whereby people of poorer background not only die sooner but spend more of their lives with disabilities. There are different methods to measure inequalities in health[3;25;29;30]. Health inequalities arise from a complex interaction of many factors, one of which is poor diet and nutrition. Health inequalities are preventable through government policies aimed at the population as a whole[28]. In general, 'downstream' preventive interventions with focus on individual behavioural changes are more likely to increase health inequalities than 'upstream' social or policy interventions[31]. Amongst the former, media campaigns may be particularly likely to increase inequalities whilst the latter tend to reduce health inequalities, as they are usually 'structural'[32;33]. Furthermore, the risk of hypertension associated with low parental social status can be modified by an improvement in social status later in life[34], suggesting effective targets for public health policies and political interventions. In a previous analysis using the National Diet and Nutrition Survey (NDNS) 2000-01, we identified significant spatial and socio-economic patterns of salt intake (measured by dietary sodium and urinary sodium) in Britain[35]. In 2,105 men and women aged 19-64 years, salt consumption was assessed using both 7-day dietary records and 24h urinary sodium excretion. Socio-economic position was defined both on head of household occupation and on participant's educational attainment. Bayesian geo-additive models via Markov Chain Monte Carlo simulations were used to test the independent associations accounting for linear and non-linear effects and spatial variations. Both dietary and total salt consumption were higher in Scotland and in lower socio-economic groups, whether assessed by occupation or by educational attainment (with difference estimates varying from 4% to 9%). As the UK program has successfully reduced the population salt intake, it is yet unknown whether this national programme has made any change in this inequality. Thus, this paper aims to examine the spatial and socio-economic patterns of salt intake using recently released UK NDNS data (2008-11), and compare the possible change of these patterns before and after the implementation of the UK salt reduction programme.

Data and Methods

This analysis was conducted using data from the 2008-11 British National Diet and Nutrition Survey (NDNS). This survey is part of a national programme set up in 1992 to provide a cross-sectional and nationally representative sample of the British population regarding diet, nutrient intake and nutritional status. Details of the fieldwork and the survey are described elsewhere[36]. In 2008, it changed to a Rolling Programme to better capture trends and to quickly meet political needs. One thousand to 1,500 people aged 1.5 to 94 years are recruited every year as a representative sample of the general population in the UK (including England, Wales, Scotland and Northern Ireland). Participants are classified into three age groups: 1.5-18 years, 19-64 years and 65 years and over. The fieldwork for the latest survey was carried out throughout 2008-11 to account for any possible seasonal variations in dietary intake. At household level, about 26% of the 9,990 issued household addresses were selected for the survey in three years. At individual level, 3,073 individuals participated in the interview by completing a series of questionnaires and measurements, including a 3- or 4-day food diary, a socio-demographic background interview, height and weight measurements, smoking and drinking assessments by self-completed questionnaires, and an assessment of physical activity by self-completed questionnaires or ActiGraph. Seventy five per cent (unweighted for age, N=2,318) of the participants were then visited by a nurse. This procedure included physical and BP measurements, a blood sample and a 24h urine collection, and collection of data on prescribed medicines. At this stage, 53% (unweighted for age, N=1,614) of the interviewed participants provided 24h urine sample (data not released to date). Of the total participants, 39% (N=1,186) were adults (19-64 years). White respondents accounted for 90% (N=1,069) of the adult population. Ethnic minority groups were excluded since estimation on few participants may not be representative of their ethnic group, particularly when compared by region. Finally participants from Northern Ireland were also excluded due to small numbers (n=42), leaving a total sample size of 1,027.

Height and weight were measured at the nearest 0.1 cm and 0.1 kg, respectively, to calculate body mass index (BMI=weight/height (kg/m^2)). BP measurements were taken three times in a sitting position. The average of the second and third reading was used as the participant's BP level. Socio-economic status (SES) was measured by two indicators, educational attainment and occupation. Educational attainment was based on the information of the highest qualification achieved. Some participants obtained foreign qualifications or were still in full-time education. Hence, a missing value was assigned to those participants. Occupation was determined by the socio-economic classification (SEC) of the household reference person (HRP). Unlike the previous cross-sectional programme (based on The Registrar-General's Social Classes), the rolling programme defines the SEC by the National Statistics Socio-economic classification (NS-SEC)[37], which is developed from the Standard Occupational Classification 2010 (SOC2010). Details of the definitions of the classification can be found in the NDNS year 3 report[38]. The NS-SEC grouped the participants into 8 occupational classes: 1) higher managerial, administrative and professional; 2) Lower managerial, administrative and professional; 3) Intermediate; 4) Small employers and own account workers; 5) Lower supervisory and technical; 6) Semi-routine; 7) Routine; and 8) Never worked and long-term unemployed. The SES information was simplified into 3-class version[39]: 1) Higher managerial, administrative and professional (containing level 1-2); 2) Intermediate (level 3-4); 3) Routine and manual (5-7). There were only 18 participants in the "Never worked and long-term unemployed" category (level 8). Hence, they were coded as missing values. Meanwhile, some participants classified as full-time students or other occupations not stated or inadequately described were also coded as missing values. Marital status included 5 categories: 1) single, 2) married and living with husband or wife, 3) married and separated, 4) divorced, 5) widowed. With the information of whether they were living with a partner, the marital status used in this analysis was coded as either living alone or living with partner. Smoking habit was derived from questions concerning current and previous smoking history. Based on their smoking history, the NDNS participants were recorded as current, former or non-smoker. Daily sodium intake was the outcome of interest. The food diary provided each participant's nutrient and energy intakes in weekdays and weekends. Sodium and energy intakes and alcohol consumption were based on the average of the 4-day dietary data. However, salt used in cooking and on the table (discretionary salt) was not measured.

Geographical boundaries

The NDNS rolling programme was conducted across the UK, including England, Scotland, Wales and Northern Ireland[40]. The regional classification of England used in the rolling programme was different to the classification used in previous surveys, particularly in the north and south east part of England, which was mainly due to the use of Government Office Regions (GORs) 2011. Details can be found on the website of the Office for National Statistics[41]. As the Bayesian models are unable to make estimation over disconnected regions (i.e. Northern Ireland and the rest of Great Britain), data collected from Northern Ireland were excluded from this study. Therefore, the analysis was limited to mainland Britain, and only boundary data of England, Scotland and Wales were collected from UKBORDERS .

Statistical Methods

Kruskal-Wallis test was used to compare the regional difference of dietary sodium intake. Bayesian geo-additive models were employed to analyse the spatial and socioeconomic patterns of sodium intake while accounting for the linear or nonlinear effects of a range of important covariates, as detailed elsewhere[35]. Four models were built and assessed. One level of each categorical factor was set as the reference level for effect assessment. Cube root transformation was used to normalise the dietary sodium intake. This was identical to the transformation used in our previous analysis[35]. Deviance information criterion (DIC) was used for model selection. The model with the smallest DIC value was preferred (**appendix 1**). The descriptive analysis and tests were conducted using SPSS v21 (IBM Corp. Armonk, NY, USA). Model estimations were conducted in BayesX Version 2.1 (07.05.2012)[42]. The statistical significance level was set as α=0.05 in the descriptive analysis and α=0.1 in the models. The West Midlands BREC (158-01-2012) approved the analysis.

RESULTS

One thousand and twenty seven white participants were included in the analysis. The age and sex adjusted characteristics of the study population are summarised in **table 1**. The mean age was 43.3 (95% confidence interval 42.5 to 44.0) years and women accounted for 56.4% (N=579) of the sample. 27.1% of the participants had a higher educational attainment, 31.1% an A level, below degree or equivalent educational attainment, and 25.5% a GCSE or equivalent educational attainment. Participants in higher social-economic groups accounted for 45.9% of the sample.

Dietary sodium

The median sodium intake was 2,245 (IQR=1,092) mg/day, which approximated to 5.6g of salt/day (100mg sodium = 0.25g salt). The median energy intake was 1,799 (IQR=761) kcal/day. **Figure 1** shows the observatory map of sodium intake by region. Sodium intake was highest in Scotland, followed by the West Midlands. The regional differences, however, were not statistically significant (p=0.145) (**table 2**).

The DIC results of the models were presented in **appendix 1**. Model 3 with linear assumption of the covariates performed the best in terms of the DIC value. Hence, the results of Model 3 were presented in **table 3**. Once adjusted for all confounders in the model, dietary sodium intake significantly decreased with age and men had higher dietary sodium intake than women. As expected, dietary sodium intake was positively associated with body mass as a result of its association with energy intake. Participants at the lowest end of educational attainment (no qualification) had significantly higher dietary sodium intake that the reference group (higher education at degree level) (5.7% [0.1%, 11.1%]; **appendix 2**). To avoid the effect of residual confounding, a set of models with 5-category occupation was also examined. No substantial change, particularly in terms of the statistical significance, was detected between the two approaches (results not shown). A similar trend (though not statistically significant) was observed between dietary sodium intake and occupation.

Comparison with the 2000-01 NDNS

Compared with the analysis of the NDNS 2000-01[35], whilst the spatial differences in dietary sodium intake in NDNS 2008-11 still followed the pattern of increasing levels from south to north (with Scotland showing the highest), the results were no longer statistically significant (**figure 1 and table 2**). Between the two surveys (almost 10 years apart) there was an average reduction in dietary sodium intake of 366mg per day (or 0.9g of salt per day).

Crucially, the socio-economic gradient remained (**figure 2**). If anything, the proportional gap appeared to widen (from 3.5% [0.1%, 7.2%] to 5.7% [0.1%, 11.1%]) between those with no qualification and the reference group (higher education at degree level)(**appendix 2**).

DISCUSSION

Our analysis confirms a socio-economic gradient in dietary salt intake in the British Isles in 2008-11 independent of a geographic gradient. In addition it shows for the first time that after 10 years of a national programme of population reduction in salt intake, social inequalities in salt consumption have remained. This study extends our original approach of analysing spatial variations of salt intake to establish the contribution of socio-economic variations and other confounders after 10 years of a population-based programme of salt reduction, thus providing a unique opportunity to evaluate effects on inequalities.

Strengths and limitations

The study has strengths. The National Diet and Nutrition Survey is a rolling programme of screening of a nationally representative sample of the British population regarding diet, nutrient intake and nutritional status. This analysis is the first evaluation of the effect of a national programme of salt reduction on social inequalities. The Bayesian approach allows us to determine spatial variations as well as the contribution of known and unknown confounders. Finally, estimates of dietary intake are reinforced by the fact that food composition tables on salt content have been updated recently.

The study has limitations. Dietary salt intake was assessed by 3- or 4-day food diaries. This is at variance with the 2000-2001 survey when dietary salt intake was assessed with 7-day dietary records[35]. Notwithstanding the general comparability of group estimates using the two methods[43;44], in this round only salt coming from food was assessed, with no inclusion of discretionary salt deriving from that added to food at the table, during the cooking process and in restaurants and other food outlets. Discretionary salt intake may account for approximately 15% of the total salt consumption[19], and additional socio-economic inequalities in salt consumption may well depend on further variations in discretionary use. Total salt intake is best measured by 24h urinary sodium excretion[45;46]. In the 2000-2001 analysis both spatial and socio-economic patterns were comparable with dietary and total salt estimates[35]. The definitions of SES were based on occupation and educational attainment. Whilst limited, these definitions are comparable to those used in 2000-2001[35]. Our results are based on white respondents, since the representation of ethnic minority groups was still insufficient for an independent analysis. The generalizability of the findings is therefore limited to whites. Limitations are also the relatively small number of spatial units and regional classifications[35]. The possibility of residual confounding cannot be ruled out completely.

Context

The UK initiated a nationwide salt reduction programme in 2003/4 based on several public awareness campaigns, setting progressing targets on the salt content of processed food led by the Food Standard Agency, a voluntary agreement with the food industry to reformulate bread and processed foods and a rolling programme of repeated surveys to monitor the salt intake of the population[11] and the salt content of some food category[24]. The programme has been successful and resulted in a 1.4g per day (15%) reduction in the English population salt consumption by 2011, as measured by 24h urinary sodium excretion (from 9.5g per day in 2003 to 8.1g per day in 2011)[22]. During the same period of time population BP fell by 3.0/1.4 mmHg (2.7/1.1 mmHg in those not on treatment for hypertension), and both stroke and IHD mortality by 36% decreased by 36%[22]. The average salt level in bread fell from 1.23g per 100g in 2001 to 0.98g per 100g in 2011, and the number of products meeting the 2012 targets increased from 28% in 2001 to 71% in 2011[24]. Our study indicates a 0.9g per day reduction in population dietary salt intake between surveys which should be interpreted as primarily deriving from food reformulation rather than by behavioural modifications in the use of discretionary salt at the table and in cooking.

Implications for policy

The diet of socio-economically disadvantaged groups is made of low-quality, salt-dense, high-fat, high-calorie unhealthy cheap foods[3;47-53]. Behavioural approach to healthy eating is unlikely to bring about the changes necessary to halt and reverse the non-communicable diseases epidemic and they may widen inequalities[11;32;54]. SES inequalities in dietary access and consumption of healthy foods are widely documented[28], both within countries[3] and between countries[55], and for salt intake are detectable in children[56] as well as adults[35]. Australian children from a low SES have on average 9% greater intake of salt from food sources compared to those from a high SES[56]. In our study these differences are estimated to be between 5% and 6%.

The findings of a sustained SES gradient in population dietary salt intake from 2000-2001 to 2008-11 is disappointing as one would have expected a larger reduction in lower SES following a population-wide approach[32]. There are multiple interpretations of these findings. First, our results do not indicate that the total salt consumption is still higher in low SES as we do not have measures of 24h urinary sodium excretion in the 2008-11 survey that are directly comparable with those taken in 2000-2001. However, in the 2000-2001 both measures (dietary sodium and 24h urinary sodium) were used and the results were consistent[35]. Second, to counterbalance the higher dietary salt intake in low SES, the same groups should have reduced discretionary salt substantially following public awareness campaigns, an effect not anticipated[32] and not reported as yet in the literature. Third, the inequalities we detect for dietary salt intake could be even greater if we assumed that the consumption of junk food from unregulated street retailers is more common in people of low SES. Indeed, recent results from the analysis of data for take-home food and beverage purchases from British households in 2010 indicates that shopping baskets of higher SES groups are healthier (proportionally more purchasing of fiber, protein and total sugars and less sodium) than those of lower SES groups[27]. Fourth, it is possible that the reformulation of food items (beyond bread) has covered disproportionately food items not predominantly purchased by low SES groups. A more detailed monitoring of household food purchasing in relation to targeted reformulation and improved access by acting on pricing should be included in surveillance methods to reveal potential targets to reduce social inequalities in salt intake. Fifth, the UK salt reduction programme started with three waves of media campaigns to increase awareness and change behaviour. The engagement with industry, which included target settings and food reformulation, was implemented later and its effects might not have had enough time to impact on social inequalities.

Conclusions

Social inequalities in salt intake have not seen a reduction following the national salt reduction programme and still explain more than 5% of salt intake between more and less affluent groups. Understanding the socio-economic pattern of salt intake is crucial to reduce inequalities. Efforts are needed to minimise the gap between socio-economic groups for an equitable delivery of cardiovascular prevention.

Contributors. FPC developed the idea, obtained funding, supervised the analysis and drafted the manuscript. CJ carried out the statistical analysis and prepared the draft methods and results. Both made significant contributions to the draft manuscript. FPC acts as guarantor.

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Table 1: Age and sex adjusted characteristics of the population of the National Diet and Nutrition Survey 2008-2011.

Variable	Total (N=1,027)
Age (year)	43.3 (42.5, 44.0)
Sex (%)	
Male	43.6
Female	56.4
Weight (kg)	78.9 (77.9, 79.8)
Height (cm)	169.5 (169.1, 169.9)
BMI (kg/m^2)	27.4 (27.0, 27.7)
Smoking habit (%)	
Non-smoker	36.0
Former smoker	36.6
Current smoker	27.4
Marital status (%)	
Living with partner	63.8
Living alone	36.2
Education attainment (%)	
Higher education	27.1
Below degree, A level or equivalent	31.1
GCSE or equivalent	25.5
No qualification	16.2
Occupation (%)	
Professional, managerial, administrative	45.9
Intermediate	20.0
Routine and manual	34.1
Sodium intake (mg/day)*	2,245 (1,092)
Energy intake (kcal/day)*	1,799 (761)
Alcohol consumption (g/day)*	6.0 (23.0)
Region (%)	
North East	4.2
North West	13.0
Yorkshire and the Humber	8.2
East Midlands	10.7
West Midlands	11.0
East of England	9.7
London	6.3
South East	15.6
South West	7.9
Wales	5.9
Scotland	7.5

Note: Results are mean (95% confidence intervals) and percentage, unless stated; BMI, body mass index; GCSE, General Certificate of Secondary Education;
*: Median with Interquartile Range.

Table 2: Dietary sodium intake (without discretionary salt consumption) by region in the 2008-2011 National Diet and Nutrition Survey sample of white participants.

Region	**Sodium intake (mg/day)** Median (IQR)	**Salt equivalent (g/day)** Median (IQR)
North East	2,106 (1,087)	5.26 (2.72)
North West	2,228 (1,104)	5.57 (2.76)
Yorkshire and the Humber	2,186 (1,193)	5.47 (2.98)
East Midlands	2,244 (1,176)	5.61 (2.94)
West Midlands	2,343 (1,167)	5.86 (2.92)
East of England	2,167 (1,103)	5.42 (2.76)
London	2,170 (1,054)	5.43 (2.64)
South East	2,179 (953)	5.45 (2.38)
South West	2,251 (987)	5.63 (2.47)
Wales	2,027 (1,073)	5.07 (2.68)
Scotland	2,447 (1,046)	6.12 (2.62)

Table 3: Fixed effect of dietary sodium intake in the 2008-2011 National Diet and Nutrition Survey sample of white participants.

Factor	Mean (90% credible interval)
Age (year)	*-0.012 (-0.018, -0.006)*
Female	0
Male	*0.342 (0.176, 0.499)*
BMI (kg/m2)	*0.018 (0.003, 0.032)*
Smoking habit	
Non	0
Former	0.107 (-0.048, 0.264)
Current	-0.044 (-0.241, 0.152)
Marital status	
Living together	0
Living alone	0.005 (-0.139, 0.158)
Education attainment	
Higher Education (degree level)	0
A level or equivalent	*0.191 (0.009, 0.380)*
GCSE or equivalent	0.159 (-0.060, 0.367)
No qualification	*0.252 (0.003, 0.486)*
Occupation	
Professional, managerial, administrative	0
Intermediate	-0.036 (-0.234, 0.158)
Routine and manual	0.109 (-0.069, 0.288)
Alcohol consumption (g/day)	*-0.009 (-0.012, -0.006)*
Energy intake (kcal/day)	*0.0019 (0.0018, 0.002)*

Note: reference level was set as 0 in each categorical variable.
The effect is significant if the entire interval does not contain 0 and it is printed in *italics*.

Figure 1. Estimated posterior mean residual spatial regional effects of dietary sodium intake. The colour band represents the range of regional effect. Shades in red/green correspond to high/low level of dietary sodium consumption.

Figure 2: The effect of education attainment (and 90% credible intervals) on dietary sodium intake in Britain in 2000-01* (top) and 2008-11 (bottom).

Note: Higher education (degree level) was used as the reference level. The effect of each educational attainment was derived by assuming a 2,500 mg dietary sodium intake per day (approximately 6.26 g/day in salt, not including discretionary salt intake) for an adult holding a degree (reference). The effect is considered significant if the entire credible interval does not include 0.

*: Although the Bayesian geo-additive models were used using the same set of factors with the same model setting, “social class” was defined using a different classification in 2000-01. In addition, the dietary sodium, energy and alcohol intakes were measured based on a 7-day dietary record in 2000-01 and on 4-day food diaries in 2008-11.

Socio-economic inequality in salt intake in Britain 10 years after a national salt reduction programme.

Chen Ji, PhD, Research Fellow and **Francesco P Cappuccio***, FRCP, DSc, Professor of Cardiovascular Medicine & Epidemiology

University of Warwick, WHO Collaborating Centre for Nutrition, Warwick Medical School, Division of Mental Health & Wellbeing, Gibbet Hill Road, Coventry, CV4 7AL

Key words: Salt intake; Salt reduction policy; Social inequalities; Socio-economic status

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Figure: ~~1~~2

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Appendix: Tables 1-2

***Correspondence to:**

Prof F P Cappuccio

University of Warwick, WHO Collaborating Centre

Warwick Medical School, Division of Mental Health & Wellbeing

Gibbet Hill, Coventry CV4 7AL, UK

f.p.cappuccio@warwick.ac.uk

ABSTRACT

Objectives. The impact of the national salt reduction programme in the UK on social inequalities is unknown. We examined spatial and socio-economic variations in salt intake in the 2008-2011 British NDNS and compared them with those before the programme in 2000-1.

Setting. Cross-sectional survey in Great Britain.

Participants. 1,027 white males and females, aged 19 to 64 years.

Primary outcome measures. Participants' dietary sodium intake measured with a 4-day food diary. Bayesian geo-additive models used to assess spatial and socio-economic patterns of sodium intake accounting for socio-demographic, anthropometric and behavioural confounders.

Results: Dietary sodium intake varied significantly across socio-economic groups, even when adjusting for geographical variations. There was higher dietary sodium intake in people with the lowest educational attainment (coeff: 0.252 [90% credible intervals 0.003, 0.486]) and in low levels of occupation (coeff: 0.109 [-0.069, 0.288]). Those with no qualification had, on average, a 5.7% [0.1%, 11.1%] higher dietary sodium intake than the reference group. Compared to 2000-01 the gradient of dietary sodium intake from south to north was attenuated after adjustments for confounders. Estimated dietary sodium consumption from food sources (not accounting for discretionary sources) was reduced by 366 mg of sodium (~0.9 g of salt) per day during the 10-year period, likely the effect of national salt reduction initiatives.

Conclusions: Social inequalities in salt intake have not seen a reduction following the national salt reduction programme and still explain more than 5% of salt intake between more and less affluent groups. Understanding the socio-economic pattern of salt intake is crucial to reduce inequalities. Efforts are needed to minimise the gap between socio-economic groups for an equitable delivery of cardiovascular prevention.

ARTICLE SUMMARY

Article focus

- To examine the spatial and socio-economic variations in salt intake in the 2008-2011 British National Diet and Nutrition Survey and to compare them with those before the implementation of a national programme of population-wide dietary salt reduction.

Key messages

- In 2008-11 people in Scotland still tend to eat more salt than those in England and Wales, as shown in 2000-2001.
- After allowing for geographic differences, dietary salt intake was higher ~~in low socio-economic groups as those in manual occupations or~~ in those with lower educational attainment and showed a tendency for being high in those in manual occupations.
- Whilst there has been a reduction in salt intake overall, ~~S~~social inequalities in salt intake have not ~~seen a reduction~~narrowed following the national salt reduction programme and still explain ~~more than~~approximately 5% of salt intake difference between more and less affluent groups.
- Care must be taken to ensure that socio-economic gaps in salt intake are not inadvertently widened by monitoring the differential policy impact of salt reduction programmes.

Strength and limitations of this study

- The National Diet and Nutrition Survey is a rolling programme of screening of a nationally representative sample of the British population regarding diet, nutrient intake and nutritional status.
- This analysis is the first evaluation of the effect of a national programme of salt reduction on social inequalities.
- The Bayesian approach allows for spatial variations as well as the contribution of known and unknown confounders to be determined.
- Estimates of dietary intake are reinforced by the parallel update of food composition tables on salt content.
- Dietary salt intake was assessed by 3- or 4-day food diaries. This is at variance with the 2000-2001 survey when dietary salt intake was assessed with 7-day dietary records.
- Only salt coming from food was assessed, with no inclusion of discretionary salt deriving from that added to food at the table, during the cooking process and in restaurants and other food outlets.
- The definitions of SES were based on occupation and educational attainment.
- Results are based on the white respondents of the survey, since the representation of ethnic minority groups is still insufficient for independent analysis.
- Limitations are also due to the relatively small number of spatial units and to regional classifications.
- Residual confounding cannot be ruled out completely

BACKGROUND

High blood pressure (BP) is the most common, yet preventable, cause of morbidity, disability and death worldwide, responsible for more than half the deaths from coronary heart disease (CHD), stroke and cardiovascular disease (CVD)[1~~1~~]. The risk of CVD is now becoming more prevalent in low-and-middle income countries[2] and, within countries, is more prevalent in socially disadvantaged groups[3]. A reduction in high BP with antihypertensive medications significantly reduces BP and CVD[4]. However, the majority of events in the population occur in the range of BP not qualifying for drug therapy[5]. A population approach to achieve small BP reductions across the whole range of BP levels would therefore avert the majority of CVD events[6~~5~~]. Finally, in low-and-middle-income countries the implementation of health care programmes of detection, management and control of hypertension with drugs are still haphazard due to high costs and lack of health care infrastructures[7;8~~6;7~~], making non-pharmacological public health programmes of primary prevention a cost-effective priority[9;10~~8;9~~].

Evidence from a variety of sources shows a consistent relationship between salt intake and BP, so that a moderate reduction in salt intake reduces BP in a dose-dependent manner, in men and women, young and old, all ethnic groups and at any level of BP[11~~10~~]. Furthermore, there is evidence to suggest that these effects on BP could lead to a significant reduction in cardiovascular events, and crucially in strokes[12;13~~11;12~~]. Several approaches can be taken to reduce population salt intake[11~~10~~] and national and international organizations have now developed policies and started population programmes aiming at a reduction in population salt intake[14~~13~~], a cost-effective prevention policy[15;16~~14;15~~] with rapidly occurring health benefits[17;18~~16;17~~].

Dietary salt, primarily sodium chloride, is commonly used for food preservation and seasoning. In most westernised countries, like the UK, approximately 75% of salt consumed is hidden in processed and restaurant foods whereas only about 15% comes from discretionary use (added at the table or in cooking by the consumer or food handler)[19~~18~~].

Driven by this evidence the UK Food Standards Agency (FSA) initiated a salt reduction program in 2003, aiming to reduce the salt intake to 6 g/day in the UK population[20~~19~~]. Later, the FSA and the Department of Health worked together with the food industry to reduce the sodium content in processed foods by setting voluntary salt reduction targets, run a public campaign to raise customer awareness and developed a food labelling scheme[21~~20~~]. After 10 years, the salt intake in the UK has decreased by 1.4 g per day, a 15% reduction, from 9.5 to 8.1 g per day[22~~21~~]. This reduction has been associated with a BP reduction of 3.0/1.4 mmHg and a parallel decline in CHD and stroke mortality[22~~21~~]. The sodium content of processed food in supermarkets has also been reduced by 20-30%[23~~22~~], particularly in packaged bread, the biggest contributor of salt intake in the British diet[24~~23~~].

Health inequalities are variations in health status across individuals in a population[25]. Health inequalities by socio-economic status are common. CVD is more prevalent in socio economically deprived populations and groups within populations. Low socio-economic status is associated with hypertension and high risks of stroke, CHD and renal failure[26~~24~~]. These groups are more likely to depend on cheaper unhealthy processed food diets, high in salt[27~~25~~]. The Marmot Review[28~~26~~] affirmed social inequalities as important determinants of ill-health in the British population, highlighting the social gradient in health inequalities, whereby people of poorer background not only die sooner but spend more of their lives with disabilities. There are different methods to measure inequalities in health[3;25;29;30]. Health inequalities arise from a complex interaction of many factors, one of which is ~~bad~~ poor diet and nutrition. Health inequalities are preventable through government policies aimed at the population as a whole[28~~26~~]. In general, 'downstream' preventive interventions with focus on individual behavioural changes are more likely to increase health inequalities than 'upstream' social or policy interventions[31]. ~~Population-based strategies for prevention~~Amongst the former, media campaigns may be particularly likely to increase inequalities whilst the latter tend to reduce health inequalities, as they are usually 'structural'[32;33~~27~~]. Furthermore, the risk of hypertension associated with low parental social status can be modified by an improvement in social status later in life[34~~28~~], suggesting effective targets for public health policies and political interventions. ~~However, effective polices are less likely to be implemented in low-and-middle income countries, as it is the case for salt reduction in the European regions[29].~~ In a previous analysis using the National Diet and Nutrition Survey (NDNS) 2000-01, we identified significant spatial and socio-economic patterns of salt intake (measured by dietary sodium and urinary sodium) in Britain[35~~30~~]. In 2,105 men and women aged 19-64 years, salt consumption was assessed using both 7-day dietary records and 24h urinary sodium excretion. Socio-economic position was defined both on head of household occupation and on participant's educational attainment. Bayesian geo-additive models via Markov Chain Monte Carlo simulations were used to test the independent associations accounting for linear and non-linear effects and spatial variations. Both dietary and total ~~S~~salt ~~intake~~consumption ~~was~~ were ~~found to be~~ higher in Scotland and in lower socio-economic groups, whether assessed by occupation or by educational attainment (with difference estimates varying from 4% to 9%). As the UK program has successfully reduced the population salt intake, it is yet unknown whether this national programme has made any change in this inequality. Thus, this paper aims to examine the spatial and socio-economic patterns of salt intake using recently released UK NDNS data (2008-11), and compare the possible change of these patterns before and after the implementation of the UK salt reduction programme.

Data and Methods

This analysis was conducted using data from the 2008-11 British National Diet and Nutrition Survey (NDNS). This survey is part of a national programme set up in 1992 to provide a cross-sectional and nationally representative sample of the British population regarding diet, nutrient intake and nutritional status. Details of the fieldwork and the survey are described elsewhere[36~~31~~]. In 2008, it changed to a ~~rolling~~ Rolling ~~programme~~ Programme to better capture trends and to quickly meet political needs. One thousand to 1,500 people aged 1.5 to 94 years are recruited every year as a representative sample of the general population in the UK (including England, Wales, Scotland and Northern Ireland). Participants are classified into three age groups: 1.5-18 years, 19-64 years and 65 years and over. The fieldwork for the latest survey was carried out throughout 2008-11 to account for any possible seasonal variations in dietary intake. At household level, about 26% of the 9,990 issued household addresses were selected for the survey in three years. At individual level, 3,073 individuals participated in the interview by completing a series of questionnaires and measurements, including a 3- or 4-day food diary, a socio-demographic background interview, height and weight measurements, smoking and drinking assessments by self-completed questionnaires, and an assessment of physical activity by self-completed questionnaires or ActiGraph. Seventy five per cent (unweighted for age, N=2,318) of the participants were then visited by a nurse. This procedure included physical and BP measurements, a blood sample and a 24h urine collection, and collection of data on prescribed medicines. At this stage, 53% (unweighted for age, N=1,614) of the interviewed participants provided 24h urine sample (data not released to date). Of the total participants, 39% (N=1,186) were adults (19-64 years). White respondents accounted for 90% (N=1,069) of the adult population. Ethnic

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minority groups were excluded since estimation on few participants may not be representative of their ethnic group, particularly when compared by region. Finally participants from Northern Ireland were also excluded due to small numbers (n=42), leaving a total sample size of 1,027.

Height and weight were measured at the nearest 0.1 cm and 0.1 kg, respectively, to calculate body mass index (BMI=weight/height (kg/m^2)). BP measurements were taken three times in a sitting position. The average of the second and third reading was used as the participant's BP level. Socio-economic status (SES) was measured by two indicators, educational attainment and occupation. Educational attainment was based on the information of the highest qualification achieved. Some participants obtained foreign qualifications or were still in full-time education. Hence, a missing value was assigned to those participants. Occupation was determined by the socio-economic classification (SEC) of the household reference person (HRP). Unlike the previous cross-sectional programme (based on The Registrar-General's Social Classes), the rolling programme defines the SEC by the National Statistics Socio-economic classification (NS-SEC)[37], which is developed from the Standard Occupational Classification 2010 (SOC2010). Details of the definitions of the classification can be found in the NDNS year 3 report[38~~32~~]. The NS-SEC grouped the participants into 8 occupational classes: 1) higher managerial, administrative and professional; 2) Lower managerial, administrative and professional; 3) Intermediate; 4) Small employers and own account workers; 5) Lower supervisory and technical; 6) Semi-routine; 7) Routine; and 8) Never worked and long-term unemployed. The SES information was simplified into 3-class version[39~~33~~]: 1) Higher managerial, administrative and professional (containing level 1-2); 2) Intermediate (level 3-4); 3) Routine and manual (5-7). There were only 18 participants in the "Never worked and long-term unemployed" category (level 8). Hence, they were coded as missing values. Meanwhile, some participants classified as full-time students or other occupations not stated or inadequately described were also coded as missing values. Marital status included 5 categories: 1) single, 2) married and living with husband or wife, 3) married and separated, 4) divorced, 5) widowed. With the information of whether they were living with a partner, the marital status used in this analysis was coded as either living alone or living with partner. Smoking habit was derived from questions concerning current and previous smoking history. Based on their smoking history, the NDNS participants were recorded as current, former or non-smoker. Daily sodium

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intake was the outcome of interest. The food diary provided each participant's nutrient and energy intakes in weekdays and weekends. Sodium and energy intakes and alcohol consumption were based on the average of the 4-day dietary data. However, salt used in cooking and on the table (discretionary salt) was not measured.

Geographical boundaries

The NDNS rolling programme was conducted across the UK, including England, Scotland, Wales and Northern Ireland[40]~~[34]~~. The regional classification of England used in the rolling programme was different to the classification used in previous surveys, particularly in the north and south east part of England, which was mainly due to the use of Government Office Regions (GORs) 2011. Details can be found on the website of the Office for National Statistics[41]~~[35]~~. As the Bayesian models are unable to make estimation over disconnected regions (i.e. Northern Ireland and the rest of Great Britain), data collected from Northern Ireland were excluded from this study. Therefore, the analysis was limited to mainland Britain, and only boundary data of England, Scotland and Wales were collected from UKBORDERS ~~Boarders~~.

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Statistical Methods

Kruskal-Wallis test was used to compare the regional difference of dietary sodium intake. Bayesian geo-additive models were employed to analyse the spatial and socioeconomic patterns of sodium intake while accounting for the linear or nonlinear effects of a range of important covariates, as detailed elsewhere[35]~~[30]~~. Four models were built and assessed. One level of each categorical factor was set as the reference level for effect assessment. Cube root transformation was used to normalise the dietary sodium intake. This was identical to the transformation used in our previous analysis[35]~~[30]~~. Deviance information criterion (DIC) was used for model selection. The model with the smallest DIC value was preferred (**appendix 1**). The descriptive analysis and tests were conducted using SPSS v21 (IBM Corp. Armonk, NY, USA). Model estimations were conducted in BayesX Version 2.1 (07.05.2012)[42]~~[36]~~. The statistical significance level was set as α=0.05 in the descriptive analysis and α=0.1 in the models. The West Midlands BREC (158-01-2012) approved the analysis.

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RESULTS

One thousand and twenty seven white participants were included in the analysis. The age and sex adjusted characteristics of the study population are summarised in **table 1**. The mean age was 43.3 (95% confidence interval 42.5 to 44.0) years and women accounted for 56.4% (N=579) of the sample. 27.1% of the participants had a higher educational attainment, 31.1% an A level, below degree or equivalent educational attainment, and 25.5% a GCSE or equivalent educational attainment. Participants in higher social-economic groups accounted for 45.9% of the sample.

Dietary sodium

The median sodium intake was 2,245 (IQR=1,092) mg/day, which approximated to 5.6g of salt/day (100mg sodium = 0.25g salt). The median energy intake was 1,799 (IQR=761) kcal/day. **Figure 1** shows the observatory map of sodium intake by region. Sodium intake was highest in Scotland, followed by the West Midlands. The regional differences, however, were not statistically significant (p=0.145) (**table 2**).

The DIC results of the models were presented in **appendix 1**. Model 3 with linear assumption of the covariates performed the best in terms of the DIC value. Hence, the results of Model 3 were presented in **table 3**. Once adjusted for all confounders in the model, dietary sodium intake significantly decreased with age and men had higher dietary sodium intake than women. As expected, dietary sodium intake was positively associated with body mass as a result of its association with energy intake. Participants at the lowest end of educational attainment (no qualification) had significantly higher dietary sodium intake that the reference group (higher education at degree level) (5.7% [0.1%, 11.1%]; **appendix 2**). To avoid the effect of residual confounding, a set of models with 5-category ~~factors~~ occupation was also examined. No substantial change, particularly in terms of the statistical significance, was detected between the two approaches (results not shown). A similar trend (though not statistically significant) was observed between dietary sodium intake and occupation.

Comparison with the 2000-01 NDNS

Compared with the analysis of the NDNS 2000-01[35~~30~~], whilst the spatial differences in dietary sodium intake in NDNS 2008-11 still followed the pattern of increasing levels from south to north (with Scotland showing the highest), the results were no longer statistically significant (**figure 1 and table 2**). Between the two surveys (almost 10 years apart) there was an average reduction in dietary sodium intake of 366mg per day (or 0.9g of salt per day). Crucially, the socio-economic gradient remained (**figure 2**). If anything, the proportional gap appeared to widen (from 3.5% [0.1%, 7.2%] to 5.7% [0.1%, 11.1%]) between those with no qualification and the reference group (higher education at degree level)(**appendix 2**).

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DISCUSSION

Our analysis confirms a socio-economic gradient in dietary salt intake in the British Isles in 2008-11 independent of a geographic gradient. In addition it shows for the first time that after 10 years of a national programme of population reduction in salt intake, social inequalities in salt consumption have remained. This study extends our original approach of analysing spatial variations of salt intake to establish the contribution of socio-economic variations and other confounders after 10 years of a population-based programme of salt reduction, thus providing a unique opportunity to evaluate effects on inequalities.

Strengths and limitations

The study has strengths. The National Diet and Nutrition Survey is a rolling programme of screening of a nationally representative sample of the British population regarding diet, nutrient intake and nutritional status. This analysis is the first evaluation of the effect of a national programme of salt reduction on social inequalities. The Bayesian approach allows us to determine spatial variations as well as the contribution of known and unknown confounders. Finally, estimates of dietary intake are reinforced by the fact that food composition tables on salt content have been updated recently.

The study has limitations. Dietary salt intake was assessed by 3- or 4-day food diaries. This is at variance with the 2000-2001 survey when dietary salt intake was assessed with 7-day dietary records[35~~30~~]. Notwithstanding the general comparability of group estimates using the two methods[43;44~~37;38~~], in this round only salt coming from food was assessed, with no inclusion of discretionary salt deriving from that added to food at the table, during the cooking process and in restaurants and other food outlets. Discretionary salt intake may

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account for approximately ~~25~~15% of the total salt consumption[19~~18~~], and additional socio-economic inequalities in salt consumption may well depend on further variations in discretionary use. Total salt intake is best measured by 24h urinary sodium excretion[45;46~~39;40~~]. In the 2000-2001 analysis both spatial and socio-economic patterns were comparable with dietary and total salt estimates[35~~30~~]. The definitions of SES were based on occupation and educational attainment. Whilst limited, these definitions are comparable to those used in 2000-2001[35~~30~~]. Our results are based on white respondents, since the representation of ethnic minority groups was still insufficient for an independent analysis. The generalizability of the findings is therefore limited to whites. Limitations are also the relatively small number of spatial units and regional classifications[35~~30~~]. The possibility of residual confounding cannot be ruled out completely.

Context

The UK initiated a nationwide salt reduction programme in 2003/4 based on several public awareness campaigns, setting progressing targets on the salt content of processed food led by the Food Standard Agency, a voluntary agreement with the food industry to reformulate bread and processed foods and a rolling programme of repeated surveys to monitor the salt intake of the population[11~~10~~] and the salt content of some food category[24~~23~~]. The programme has been successful and resulted in a 1.4g per day (15%) reduction in the English population salt consumption by 2011, as measured by 24h urinary sodium excretion (from 9.5g per day in 2003 to 8.1g per day in 2011)[22~~21~~]. During the same period of time population BP fell by 3.0/1.4 mmHg (2.7/1.1 mmHg in those not on treatment for hypertension), and both stroke and IHD mortality by 36% decreased by 36%[22~~21~~]. The average salt level in bread fell from 1.23g per 100g in 2001 to 0.98g per 100g in 2011, and the number of products meeting the 2012 targets increased from 28% in 2001 to 71% in 2011[24~~23~~]. Our study indicates a 0.9g per day reduction in population dietary salt intake between surveys which should be interpreted as primarily deriving from food reformulation rather than by behavioural modifications in the use of discretionary salt at the table and in cooking.

Implications for policy

The diet of socio-economically disadvantaged groups is made of low-quality, salt-dense, high-fat, high-calorie unhealthy cheap foods[3;47-53]. Behavioural approach to healthy eating is unlikely to bring about the changes necessary to halt and ~~revert~~ reverse the non-communicable diseases epidemic and they may widen inequalities[11;32;54]~~[10;27;41]~~. SES inequalities in dietary access and consumption of healthy foods are widely documented[28]~~[26]~~, both within countries[3] and between countries[55]~~[29]~~, and for salt intake are detectable in children[56]~~[42]~~ as well as adults[35]~~[30]~~. Australian children from a low SES have on average 9% greater intake of salt from food sources compared to those from a high SES[56]~~[42]~~. In our study these differences are estimated to be between 5% and 6%.

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The findings of a sustained SES gradient in population dietary salt intake from 2000-2001 to 2008-11 is disappointing as one would have expected a larger reduction in lower SES following a population-wide approach[32]~~[27]~~. There are multiple interpretations of these findings. First~~ly~~, our results do not indicate that the total salt consumption is still higher in low SES as we do not have measures of 24h urinary sodium excretion in the 2008-11 survey that are directly comparable with those taken in 2000-2001. However, in the 2000-2001 both measures (dietary sodium and 24h urinary sodium) were used and the results were consistent[35]~~[30]~~. Second~~ly~~, to counterbalance the higher dietary salt intake in low SES, the same groups should have reduced discretionary salt substantially following public awareness campaigns, an effect not anticipated[32]~~[27]~~ and not reported as yet in the literature. Third~~ly~~, the inequalities we detect for dietary salt intake could be even greater if we assumed that the consumption of junk food from unregulated street retailers is more common in people of low SES. Indeed, recent results from the analysis of data for take-home food and beverage purchases from British households in 2010 indicates that shopping baskets of higher SES groups are healthier (proportionally more purchasing of fiber, protein and total sugars and less sodium) than those of lower SES groups[27]~~[25]~~. Fourth~~ly~~, it is possible that the reformulation of food items (beyond bread) has covered disproportionately food items not predominantly purchased by low SES groups. A more detailed monitoring of household food purchasing in relation to targeted reformulation and improved access by acting on pricing should be included in surveillance methods to reveal potential targets to reduce social inequalities in salt intake. Fifth, the UK salt reduction programme started with three waves of media campaigns to increase awareness and change behaviour. The engagement with industry, which included target settings and food reformulation, was implemented later and its effects might not have had enough time to impact on social inequalities.

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Conclusions

Social inequalities in salt intake have not seen a reduction following the national salt reduction programme and still explain more than 5% of salt intake between more and less affluent groups. Understanding the socio-economic pattern of salt intake is crucial to reduce inequalities. Efforts are needed to minimise the gap between socio-economic groups for an equitable delivery of cardiovascular prevention.

Contributors. FPC developed the idea, obtained funding, supervised the analysis and drafted the manuscript. CJ carried out the statistical analysis and prepared the draft methods and results. Both made significant contributions to the draft manuscript. FPC acts as guarantor.

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Ethical approval. West Midlands BREC (158-01-2012)

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Table 1: Age and sex adjusted characteristics of the population of the National Diet and Nutrition Survey 2008-2011.

Variable	Total (N=1,027)
Age (year)	43.3 (42.5, 44.0)
Sex (%)	
Male	43.6
Female	56.4
Weight (kg)	78.9 (77.9, 79.8)
Height (cm)	169.5 (169.1, 169.9)
BMI (kg/m^2)	27.4 (27.0, 27.7)
Smoking habit (%)	
Non-smoker	36.0
Former smoker	36.6
Current smoker	27.4
Marital status (%)	
Living with partner	63.8
Living alone	36.2
Education attainment (%)	
Higher education	27.1
Below degree, A level or equivalent	31.1
GCSE or equivalent	25.5
No qualification	16.2
Occupation (%)	
Professional, managerial, administrative	45.9
Intermediate	20.0
Routine and manual	34.1
Sodium intake (mg/day)*	2,245 (1,092)
Energy intake (kcal/day)*	1,799 (761)
Alcohol consumption (g/day)*	6.0 (23.0)
Region (%)	
North East	4.2
North West	13.0
Yorkshire and the Humber	8.2
East Midlands	10.7
West Midlands	11.0
East of England	9.7
London	6.3
South East	15.6
South West	7.9
Wales	5.9
Scotland	7.5

Note: Results are mean (95% confidence intervals) and percentage, unless stated; BMI, body mass index; GCSE, General Certificate of Secondary Education;
*: Median with Interquartile Range.

Table 2: Dietary sodium intake (without discretionary salt consumption) by region in the 2008-2011 National Diet and Nutrition Survey sample of white participants.

Region	Sodium intake (mg/day) Median (IQR)	Salt equivalent (g/day) Median (IQR)
North East	2,106 (1,087)	5.26 (2.72)
North West	2,228 (1,104)	5.57 (2.76)
Yorkshire and the Humber	2,186 (1,193)	5.47 (2.98)
East Midlands	2,244 (1,176)	5.61 (2.94)
West Midlands	2,343 (1,167)	5.86 (2.92)
East of England	2,167 (1,103)	5.42 (2.76)
London	2,170 (1,054)	5.43 (2.64)
South East	2,179 (953)	5.45 (2.38)
South West	2,251 (987)	5.63 (2.47)
Wales	2,027 (1,073)	5.07 (2.68)
Scotland	2,447 (1,046)	6.12 (2.62)

Table 3: Fixed effect of dietary sodium intake in the 2008-2011 National Diet and Nutrition Survey sample of white participants.

Factor	Mean (90% credible interval)
Age (year)	*-0.012 (-0.018, -0.006)*
Female	0
Male	*0.342 (0.176, 0.499)*
BMI (kg/m2)	*0.018 (0.003, 0.032)*
Smoking habit	
Non	0
Former	0.107 (-0.048, 0.264)
Current	-0.044 (-0.241, 0.152)
Marital status	
Living together	0
Living alone	0.005 (-0.139, 0.158)
Education attainment	
Higher Education (degree level)	0
A level or equivalent	*0.191 (0.009, 0.380)*
GCSE or equivalent	0.159 (-0.060, 0.367)
No qualification	*0.252 (0.003, 0.486)*
Occupation	
Professional, managerial, administrative	0
Intermediate	-0.036 (-0.234, 0.158)
Routine and manual	0.109 (-0.069, 0.288)
Alcohol consumption (g/day)	*-0.009 (-0.012, -0.006)*
Energy intake (kcal/day)	*0.0019 (0.0018, 0.002)*

Note: reference level was set as 0 in each categorical variable.
The effect is significant if the entire interval does not contain 0 and it is printed in *italics*.

Figure 1. Estimated posterior mean residual spatial regional effects of dietary sodium intake. The colour band represents the range of regional effect. Shades in red/green correspond to high/low level of dietary sodium consumption.

Figure 2: The effect of education attainment (and 90% credible intervals) on dietary sodium intake in Britain in 2000-01* (top) and 2008-11 (bottom).

Note: Higher education (degree level) was used as the reference level. The effect of each educational attainment was derived by assuming a 2,500 mg dietary sodium intake per day (approximately 6.26 g/day in salt, not including discretionary salt intake) for an adult holding a degree (reference). The effect is considered significant if the entire credible interval does not include 0.
*: Although the Bayesian geo-additive models were used using the same set of factors with the same model setting, "social class" was defined using a different classification in 2000-01. In addition, the dietary sodium, energy and alcohol intakes were measured based on a 7-day dietary record in 2000-01 and on 4-day food diaries in 2008-11.

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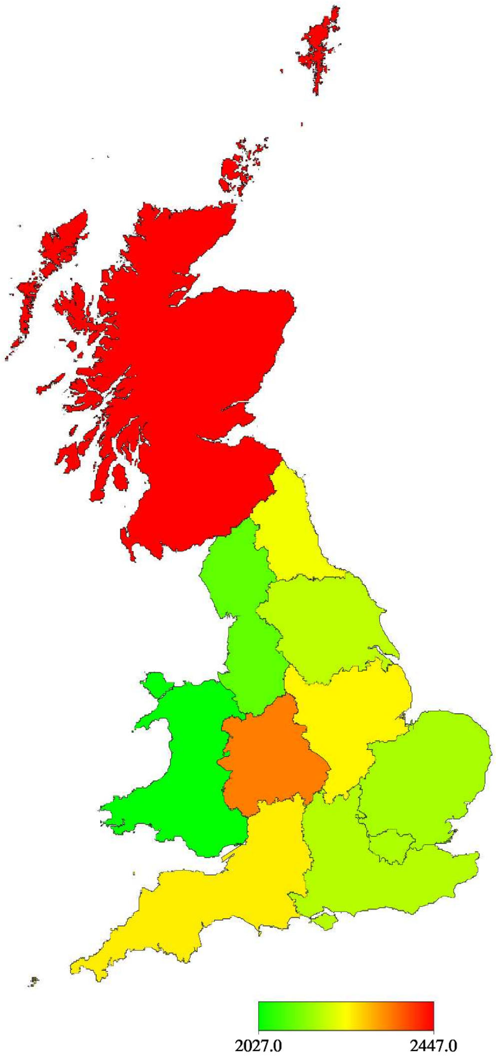

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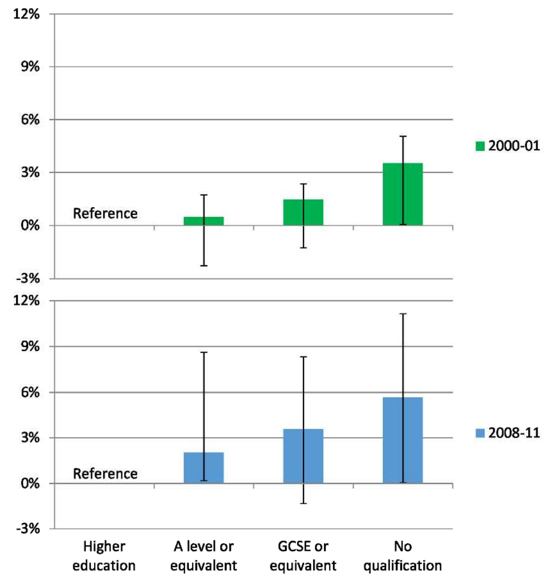

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Table Appendix 1: Model comparison.

	Model 1	Model 2	Model 3	Model 4
Deviance	1016.58	938.9	586.5	574.8
pD	8.1	12.4	20.5	32.7
DIC	1032.8	963.8	627.6	640.1

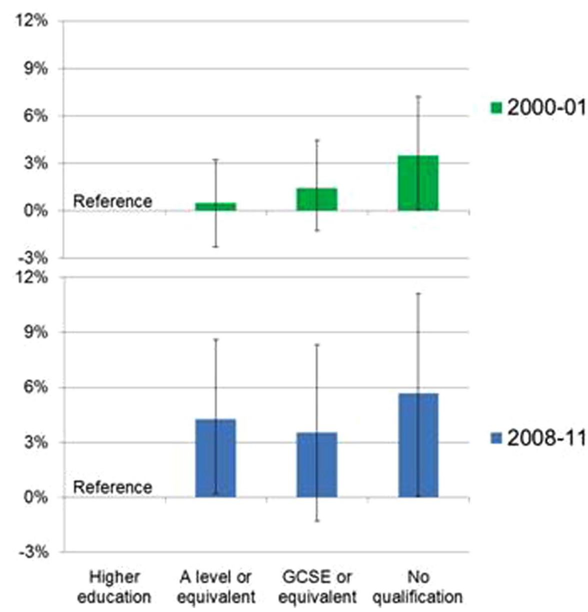
Note: Model 1= Region only; Model 2 = Model 1 + Age + Sex + Body Mass Index + Energy intake; Model 3 = Model 2 + Smoking habit + Education + Socio-economic status + Marital status + Alcohol consumption; Model 4 = Model 3 with nonlinear assumption on all continuous variables (Age, BMI, Energy intake, Alcohol consumption).

Table Appendix 2. Estimated coefficients of each level of education attainment in 2000-01 and 2008-11 using the assumption of 2,500 mg/day intake of dietary sodium.

	Mean % change	90% Credible interval	
	2000-01		
Higher education	Reference		
A level or equivalent	0.5%	-2.3%	3.3%
GCSE or equivalent	1.4%	-1.3%	4.5%
No qualification	3.5%	0.1%	7.2%
	2008-11		
Higher education	Reference		
A level or equivalent	2.0%	0.2%	8.6%
GCSE or equivalent	3.6%	-1.3%	8.3%
No qualification	5.7%	0.1%	11.1%

Correction

Ji C, Cappuccio FP. Socioeconomic inequality in salt intake in Britain 10 years after a national salt reduction programme. *BMJ Open* 2014;4:e005683. The authors have become aware that during the submission process the incorrect figure 2 was uploaded and subsequently published. The figure does not match the data reported in table 3, which is indeed correct and it is referred to for the results of the study and discussion. Whilst the mistake is uninfluential, the figure may be misleading for some. The amended figure is below. The legend is unaffected.



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