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Dietary sodium intake is associated with socioeconomic status in Australian children: a cross-sectional study

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Data sharing statement:

The authors declare that on request all data files are available for analysis from the corresponding author at carley.grimes@deakin.edu.au

ABSTRACT

Objective: To assess the association between socioeconomic status (SES) and dietary sodium intake, and identify if the major dietary sources of sodium differ by socioeconomic group in a nationally representative sample of Australian children.

Design: Cross-sectional survey.

Setting: 2007 Australian National Children's Nutrition and Physical Activity Survey.

Participants: A total of 4487 children aged 2-16 years completed all components of the survey.

Primary and secondary outcome measures: Sodium intake was determined via one 24-hr dietary recall. The population proportion formula was used to identify the major sources of dietary salt. SES was defined by the level of education attained by the primary carer. In addition parental income was used as a secondary indicator of SES.

Results: Dietary sodium intake of children of low SES background was 2576 (SEM 42) mg/d (salt equivalent 6.6 (0.1) g/d) which was greater than children of high SES background 2370 (35) mg/d (salt 6.1 (0.09) g/d) ($P<0.001$). After adjustment for age, gender, energy intake and body mass index, low SES children consumed 195 mg/d (salt 0.5 g/d) more sodium than high SES children ($P<0.001$). Low SES children had a greater intake of sodium from processed meat, gravies/sauces, pastries, breakfast cereals, potatoes and potato snacks (all $P<0.05$).

Conclusion: Australian children from a low SES background have on average a 9% greater intake of sodium from food sources compared to those from a high SES background. This socioeconomic patterning of salt intake may in turn influence the SES disparity seen in

hypertension and cardiovascular risk in adulthood. Understanding these differences in childhood risk provide important focus for intervention.

Article summary:

Article focus

- To assess the association between socioeconomic status (SES) and dietary sodium intake in Australian children and adolescents.
- To determine if the major dietary sources of sodium differ by socioeconomic group.

Key messages

- In Australian children socioeconomic status is inversely associated with dietary sodium intake.
- Children of low socioeconomic background consumed more sodium from convenience style foods including pies/sausage rolls; savoury sauces, fried prepared potato; processed meat and potato crisps.

Strengths and limitations of this study

- These results are based on a large nationally representative sample of Australian children and adolescents.
- Sodium intake was determined via a 24-hr dietary recall and therefore does not capture the amount of sodium derived from salt used at the table or during cooking.
- The socioeconomic disparity of sodium intake reported in this study is attributable to differences in sodium intake from food sources only. Further research is required to understand the influence of SES on total daily sodium intake.

INTRODUCTION

As in adults,[1] dietary sodium intake is positively associated with blood pressure in children.[2, 3] Comparable to other developed nations,[4] dietary sodium intake of Australian children is high and exceeds dietary recommendations.[5, 6] Given blood pressure follows a tracking pattern over the life course,[7, 8] it is likely that high sodium consumption during childhood increases future risk of adult hypertension and subsequent cardiovascular disease (CVD). Increased CVD risk is also observed with low SES, [9, 10] potentially due in part to differences in dietary intakes. Furthermore, prolonged inequalities of SES across the life course are likely to accumulate to overall greater CVD risk, [11, 12] A number of studies in adults[13-15] and in children and adolescents[16-20] have identified SES as a determinant of diet quality. For instance, evidence from cross-sectional studies in children and adolescents have reported a positive association between SES and fruit and vegetable intake[17, 18, 21] and conversely, lower levels of SES have been associated with poor dietary outcomes, including greater intake of high fat foods,[20] fast foods and soft drinks.[19] Studies examining the association between SES and sodium intake are scarce and inconsistent, one study in British adults found low SES was associated with higher intakes of sodium, [22] whereas in US adults there was no association between SES and sodium intake. [23] The aim of this study was to examine the association between SES and dietary sodium intake and the food sources of sodium in a nationally representative sample of Australian children aged 2-16 years.

METHODS

Study design

The 2007 Australian Children's Nutrition and Physical Activity Survey (CNPAS) was a cross-sectional survey designed to collect demographic, dietary, anthropometric and physical activity data from a nationally representative sample of children aged 2-16 years. The full details of the sampling methodology can be found elsewhere.[24] Briefly, participants were recruited using a multistage quota sampling framework. The initial target quota was 1000 participants for each of the following age groups; 2-3, 4-8, 9-13 and 14-16 years (50% boys and 50% girls), to which a 400 booster sample was later provided by the state of South Australia. The primary sampling unit was postcode and clusters of postcodes were randomly selected as stratified by state/territory and by capital city statistical division or rest of state/territory. Randomly selected clusters of postcodes ensured an equal number of participants in each age group, from each of the metro and non-metro areas within each state. Within selected postcodes Random Digit Dialling (RDD) was used to invite eligible households, i.e. those with children aged 2-16 years, to participate in the study. Only one child from each household could participate in the study. The response rate of eligible children was 40%. Due to the non-proportionate nature of the sampling framework each participant was assigned a population weighting which weighted for age, gender and region. The study was approved by the National Health and Medical Research Council registered Ethics Committees of Commonwealth Scientific and Industrial Research Organisation and the University of South Australia. All participants, or where the child was aged <14 years the primary carer, provided written consent.[24]

Assessments

Demographic and food intake data was collected during a face to face computer assisted personal interview (CAPI) completed during February and August 2007. A three-pass 24 h

dietary recall was used to determine all food and beverages consumed from midnight to midnight on the day prior to the interview.[24] The primary carer of participants aged 9 years and under provided information on dietary intake.[24] Sodium intake was calculated using the Australian nutrient composition database AUSNUT2007, specifically developed by the Food Standards Australia and New Zealand for the CNPAS.[25] Daily sodium (mg) intake was converted to the salt equivalent (g) using the conversion 1 gram of sodium chloride (salt) = 390 mg sodium. Reported salt intake did not include salt added at the table or during cooking.

The highest level of education attained by the primary carer was used to define SES. Based on this participants were grouped into one of three categories of SES; i) high: includes those with a university/tertiary qualification ii) mid: includes those with an advanced diploma, diploma or certificate III/IV or trade certificate iii) low: includes those with some or no level of high school education. Parental income was used as a secondary indicator of SES. Reported parental income before tax was grouped into four categories i) AUD$ 0 to $31 999 ii) $31 200 to $51 999 iii) $52 000 to $103 999 iv) ≥ $104 000. Body weight and height were measured using standardised protocols.[26] BMI was calculated as body weight (kg) divided by the square of body height (m^2). Participants were grouped into weight categories (very underweight, underweight, healthy weight, overweight, obese) using the International Obesity Task Force BMI reference cut offs for children.[27, 28]

Statistical analysis

Statistical analyses were completed using STATA/SE 11 (StataCorp, College Station, Texas USA) and PASW Statistics 17.0 (PASW Inc, Chicago, IL, USA). A *P* value of <0.05 was considered significant. All analyses accounted for the complex survey design using the STATA svy command, specifying strata variable (region), cluster variable (post code) and population weighting (age, gender, region). Descriptive statistics are presented as mean (SD) or n (% weighted). To assess the association between SES, as defined by primary carer education level, and sodium intake, multiple regression analysis was used with adjustment for age, gender, energy intake and BMI. To further control for the effects of age, the analysis was repeated stratified by age group (i.e. 2-3; 4-8; 9-13; 14-16 years). These age categories are consistent with those used in Australian dietary guidelines [(6)]. As income level is sometimes used as a marker of SES [(13)] the association between parental income and sodium intake was also examined, with adjustment for age, gender, energy intake and BMI. The regression coefficient (β) with 95% CI, corresponding *P* values and the coefficient of determination (R^2) are presented. In a previous analysis[(29)] which included the same study population we used the population proportion formula[(30)] to calculate the contribution of sodium from sub-major food group categories, as defined in the CNPAS food group coding system.[(24)] For the present study, we have utilised this list which identifies the main sources of dietary sodium, to determine if sodium intake from food group differs between low and high SES categories, based on primary carer education level. To do this, we calculated the mean sodium intake from each sub-major food group by SES category, and compared the mean sodium of low to high SES, using an independent T-test.

RESULTS

Basic characteristics of the 4 487 participants are listed in **Table 1**. As defined by parental education status, the proportion of children from low, mid and high SES background was relatively evenly distributed. Over two thirds of children fell within the two highest income bands. Average daily sodium intake differed by SES (**Figure 1**, P <0.01). Regression analysis indicated that low SES was associated with a 195 mg/d (salt 0.5 g/d) greater intake of sodium. The association between SES and sodium intake remained after adjustment for age, gender, energy intake and BMI (**Table 2**). When stratified by age group the association between sodium intake and SES remained significant between the ages of 4-13 years (**Table 2**), however there was no association between sodium intake and SES in 2-3 year olds or in 14-16 year olds (data not shown). There was no association between sodium intake and parental income (data not shown), however, only 28% of children fell within the two lowest income bands (**Table 1**)

Table 3 lists those sub-major food groups which contributed >1% to the groups' total daily sodium intake. Combined these 23 food groups accounted for 84.5% of total daily sodium intake. Regular breads and bread rolls contributed the most sodium. Moderate sources of sodium, contributing more than 4% of total sodium intake, included mixed dishes where cereal is the major ingredient (e.g. pizza, hamburger, sandwich, savoury rice and noodle based dishes), processed meat, gravies and savoury sauces, pastries, cheese, and breakfast cereals and bars. Compared to children of high SES, children of low SES had a significantly greater intake of sodium from processed meat, gravies and savoury sauce, pastries, breakfast cereals and bars, potatoes and potato snacks (e.g. potato crisps). The percentage difference in sodium intake in each of these categories was 46%, 31%, 24%, 16%, 39% and 46%, respectively **(Table 3).** Conversely, children of high SES background had a significantly greater intake of sodium from the food group containing cakes, buns, muffins, scones, cake-type desserts; and the food group described as batter-based products (e.g. pancakes, picklets). The percentage difference in sodium intake in each of these categories was 16% and 32%, respectively (**Table 3**).

DISCUSSION

In a nationally representative sample of Australian children aged 2-16 years, we found children of low SES background consumed 9% more dietary sodium than those of high SES background. The inverse association between sodium intake and SES was primarily driven by the association in children aged 4-13 years, particularly after adjustment for the important covariates age, gender, energy intake and BMI. In adult studies, low SES has been associated with more frequent consumption of high salt foods, such as soup, sauces, ready to eat meals, savoury seasonings, sausages and potato.(31, 32) Given parental control over children's food choices during these years, it is likely that SES disparities in adult food choices relating to high salt foods may filter down into children's eating practices. We found no association between SES and sodium intake in 2-3 and 14-16 year olds. Although some evidence indicates SES disparities in dietary patterns may be present during infancy,(33) it is possible such early differences are not seen in dietary patterns with the restricted range of food types. In the case of adolescents, as autonomy over food choices increases, other factors, such as peer-influence, taste and eating away from the home(34) may become more prominent determinants of dietary intake.

Using US National Health and Nutrition Examination Survey (NHANES) data, Mazur et al.[35] explored the association of SES, as indicated by head of household education status and household income, on sodium intake in Hispanic children aged 4-16 years. Interestingly, in this study lower levels of education were associated with lower sodium intake[35]. This is contrary to our own findings as well as past studies, which generally link lower SES to overall poorer dietary outcomes.[13] We found no association between sodium intake and level of income, however low income bands were underrepresented. This is in contrast to the findings in Hispanic children, where low household income was associated with a greater intake of dietary sodium.[35] In a New Zealand food survey, low cost 'home brand' labelled food products were found to contain greater quantities of sodium than the more expensive branded food products.[36] The impact of income on sodium intake in Australian children remains unclear and further research is required.

Previous studies in children have reported socioeconomic differences in the consumption of certain food groups.[37, 38] For example, in European children of low SES background, greater intake of starchy foods, meat products, savoury snacks such as hamburgers, sugar and confectionary, pizza, desserts and soft drinks have been reported.[37, 38] In the present study those food groups which were found to contribute more sodium to the diets of low SES children tended to include convenience style foods (i.e. pies/sausage rolls; savoury sauce and casserole base sauces; fried prepared potato; processed meat; potato snacks). Comparably, children of high SES background consumed greater amounts of sodium from cake and baked type products. However, a significant amount of sodium in baked products can be in sodium bicarbonate rather than in the form of sodium chloride. Sodium bicarbonate, unlike sodium chloride, has not been directly associated with adverse blood pressure outcomes.[39]

With reference to sodium intake data by age group[5] and comparison to the recommended daily Upper Limit of sodium[6] it is evident that Australian children of all ages across all SES backgrounds are consuming too much dietary sodium. However, for the first time our findings indicate that socioeconomic disparities exist in sodium intake in Australian children aged 9-13 years. To reduce sodium intake in children a comprehensive approach is required, firstly targeting food policy, to encourage product reformulation of lower sodium food products across all price ranges within the food supply. Secondly, consumer education and awareness campaigns, that encourage food choices which are based on fresh products with minimal processing; this may require strategies that equip parents with enhanced food preparation skills and knowledge of the 'hidden' salt added to many commonly eaten processed foods. Furthermore, it is apparent that these strategies need to reach lower SES groups.

The major strengths of this study include the use of a large nationally-representative sample of Australian children, with comprehensive and standardised collection of dietary intake. Limitations of the study include the use of a 24-hr dietary recall which fails to capture the amount of salt coming from salt added at the table and during cooking and therefore is likely to underestimate the true value of salt intake.[40] The majority (77%) of dietary sodium consumed is from salt added to processed foods, whilst a smaller amount (11%) has been found to be derived from salt added at the table and during cooking.[41] In the present study, the higher intake of sodium reported in children from low SES background is attributable to differences in sodium intake from food sources only. In a previous analysis of this data, we found that children from low SES background (25%) were more likely to report adding salt at the table than children from high SES (33%).[29] Thus, it is likely that children of low SES background are consuming greater amounts of total daily sodium than reported in the present analysis.

In summary, the findings of higher salt intakes in children of lower SES background, within in a nationally representative sample, provides focus for concern regarding salt related disease across the life course. This socioeconomic patterning of salt intake may in turn influence the SES disparity seen in hypertension and cardiovascular risk in adulthood. To reduce socioeconomic inequalities in health, interventions need to begin early in life and should include product reformulation of lower sodium food products across all price ranges, as well as consumer education and awareness campaigns which reach low SES groups.

Contributorship statement: The author's responsibilities were as follows – CAG, KJC, LJR and CAN designed research; CAG performed statistical analysis and wrote the manuscript and is guarantor of the paper; LJR, KJC and CAN helped with data interpretation, revision of manuscript and provided significant consultation. All authors have read and approved the final manuscript.

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Table 1. Basic characteristics of Australian children and adolescents aged 2-16 years (n 4 487)

Characteristic	**n or mean**	**% or SD**
Male (n %)	2 249	51
Age (years) (mean SD)	9.1	4.3
Age group (n %)		
2-3 years	1071	12
4-8 years	1216	34
9-13 years	1110	33
14-16 years	1090	21
Socioeconomic status (n %)*		
Low SES	1414	30
Mid SES	1583	36
High SES	1490	34
Parental income (n %)†		
$0 to 31 999	500	11
$32 000 to 51 999	732	17
$52 000 to 103 999	1850	42
$≥104 000	1169	30
Weight status (n %)‡		
Underweight	212	5
Healthy weight	3267	72
Overweight	761	17
Obese	247	6
Energy (kJ/d) (mean SD)	8392	3156
Sodium (mg/d) (mean SD)	2473	1243
Salt equivalent (g/d) (mean SD)§	6.3	3.1

 SES as defined by the highest level of education attained by the primary carer

†Participants with missing information for parental income (n=236) excluded

‡Weight classification based on the International Obesity Task Force BMI reference cut offs (27, 28)

§Salt equivalents (i.e. sodium chloride: 1 g = 390 mg sodium)

Figure 1. Mean sodium intake (mg/d) by socioeconomic group (n = 4487)†

[JPEG IMAGE ATTACHED]

* Significantly different from high SES (*P* <0.001)

** Significantly different from high SES (*P* <0.05)

†SES as defined by the highest level of education attained by the primary carer

Table 2. Association between socioeconomic status (SES) and dietary sodium intake (390 mg/d) (1 g/d salt) in Australian children and adolescents aged 2-16 years (n 4 487) †

Variable	**Total Sample (n=4 487)**		**Age group‡**			
			4-8 years (n=1 216)		**9-13 years (n=1 110)**	
	β (95% CI)	**P Value**	**β (95% CI)**	**P Value**	**β (95% CI)**	**P Value**
Unadjusted						
High SES (reference)						
Mid SES	0.3 (0.03, 0.5)	0.03	0.2 (-0.1, 0.6)	0.17	0.2 (-0.2, 0.6)	0.319
Low SES	0.5 (0.3, 0.8)	<0.001	0.5 (0.1, 1.0)	0.02	0.5 (-0.02, 1.0)	0.06
	R^2=0.004	<0.01	R^2=0.008	0.05	R^2=0.004	0.16
Adjusted§						

High SES (reference)						
Mid SES	0.2 (0.01, 0.4)	0.04	0.2 (-0.1, 0.4)	0.13	0.2 (-0.2, 0.6)	0.23
Low SES	0.5 (0.2, 0.7)	<0.001	0.6 (0.2, 0.9)	0.001	0.6 (0.1, 1.0)	0.01
	R^2=0.49	<0.001	R^2=0.37	<0.001	R^2=0.36	<0.001

□ Dependent variable is sodium intake in units of 390 mg/d (salt equivalent 1 g/d) and independent variable is SES entered as an indicator variable: high SES is the reference category

†SES as defined by the highest level of education attained by the primary carer

‡No association between salt intake and SES in age groups 2-3 years and 14-16 years (models not shown)

§Adjusted for gender, age, energy intake and BMI

Table 3. Dietary sources of sodium intake listed by their contribution to intake for the group and mean daily sodium intake by food group, by socioeconomic group

Food group	Total sample (n 4487)	SES Group†			
		Low (n 1414)	Mid (n 1583)	High (n 1490)	P value‡
	% contribution to total daily sodium intake	Mean sodium (SD) mg/d	Mean sodium (SD) mg/d	Mean sodium (SD) mg/d	
Regular breads and bread rolls	13.4	340 (315)	330 (300)	324 (317)	0.26
Mixed dishes where cereal is the major ingredient	8.7	214 (514)	256 (616)	172 (445)	0.07
Processed meat§	**7.6**	**216 (464)**	**180 (403)**	**168 (368)**	**0.02**
Gravies and savoury sauces	**6.5**	**182 (385)**	**166 (395)**	**139 (354)**	**0.01**
Pastries¶	**4.9**	**135 (400)**	**120 (352)**	**109 (345)**	**0.03**

Cheese	4.6	114 (209)	110 (190)	116 (186)	0.80
Breakfast cereals and bars	**4.2**	**113 (176)**	**101 (166)**	**97 (161)**	**0.03**
Dairy milk	3.9	95 (106)	94 (103)	100 (98)	0.25
Herbs, spices, seasonings and stock cubes	3.7	114 (482)	75 (246)	90 (301)	0.31
Sausages, frankfurts and saveloys	2.9	79 (259)	74 (136)	61 (201)	0.07
Mixed dishes where poultry/game is the major component	2.6	79 (268)	59 (194)	60 (238)	0.09
Soup (prepared, ready to eat)	2.6	51 (288)	74 (379)	65 (282)	0.25
English-style muffins, flat breads, and savoury sweet breads	2.4	55 (158)	58 (180)	67 (181)	0.17
Cakes, buns, muffins, scones,	**2.3**	**54 (153)**	**52 (144)**	**68 (176)**	**0.02**

cake-type desserts					
Savoury biscuits	2.2	49 (136)	57 (147)	57 (152)	0.34
Yeast, yeast, vegetable and meat extracts	2.0	47 (117)	55 (143)	45 (108)	0.70
Potatoes▯ ▯ ▯ ▯	**1.9**	**53 (128)**	**51 (127)**	**38 (106)**	**0.01**
Batter-based products††	**1.7**	**38 (161)**	**37 (150)**	**50 (180)**	**0.05**
Potato snacks	**1.7**	**51 (149)**	**40 (121)**	**35 (125)**	**0.03**
Pasta and pasta products	1.4	35 (142)	32 (130)	35 (138)	0.89
Sweet biscuits	1.2	29 (64)	33 (72)	27 (62)	0.61
Mixed dishes where beef, veal or lamb is the major component	1.1	32 (175)	21 (116)	28 (56)	0.53
Mature legumes and pulse	1.0	21 (149)	21 (137)	35 (258)	0.12

products and dishes

 Includes those sub-major food group categories that contribute >1.0% of sodium to daily intake ambiguous

†SES as defined by the highest level of education attained by the primary carer

‡Means are compared between low and high SES groups using independent T-test

§includes ham, bacon and processed delicatessen meat

includes pasta sauces and casserole bases

¶includes pies and sausage rolls

  includes potato gems and wedges

††includes pancakes and pikelets

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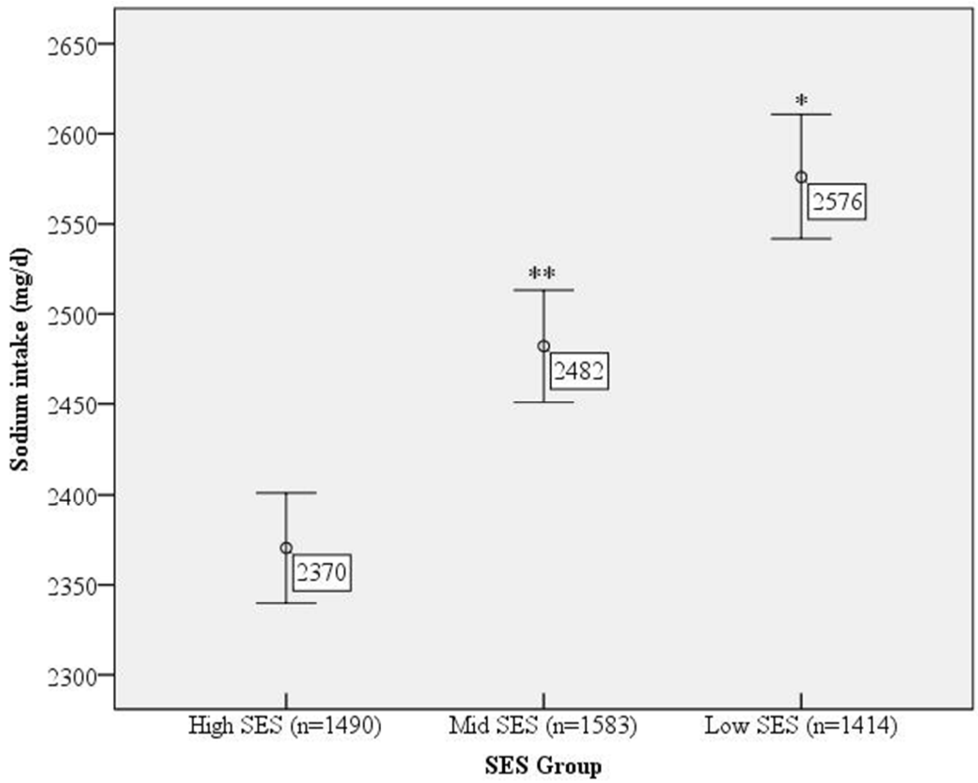

* Significantly different from high SES (P <0.001)
** Significantly different from high SES (P <0.05)
†SES as defined by the highest level of education attained by the primary carer
220x176mm (72 x 72 DPI)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Is socioeconomic status associated with dietary sodium intake in Australian children? A cross-sectional study

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Is socioeconomic status associated with dietary sodium intake in Australian children? A cross-sectional study

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Short title:

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Sodium, Dietary; Sodium Chloride; Socioeconomic Status; Child; Australia

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Declaration of competing interests:

All authors have completed the Unified Competing Interest form atwww.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare: Carley Grimes had financial support in the form of a post graduate scholarship from the Heart Foundation, Australia for the submitted work; and had no financial relationships with any organisations that might have an interest in the submitted work in the previous three years, no other relationships or activities that could appear to have influenced the submitted work. Karen Campbell had no support from any organisation for the submitted work; no other relationships or activities that could appear to have influenced the submitted work. Caryl Nowson has received research funds from Meat & Livestock Australia; National Health and Medical Research Council, Wicking Foundation, National Heart Foundation, Australia, Helen MacPerhson Smith Trust and Red Cross Blood Bank. These payments are unrelated to the submitted work. Lynn Riddell has received research funds from Meat & Livestock Australia. These payments are unrelated to the submitted work.

Data sharing statement:

The authors declare that on request all data files are available for analysis from the corresponding author at carley.grimes@deakin.edu.au

ABSTRACT

Objective: To assess the association between socioeconomic status (SES) and dietary sodium intake, and identify if the major dietary sources of sodium differ by socioeconomic group in a nationally representative sample of Australian children.

Design: Cross-sectional survey.

Setting: 2007 Australian National Children's Nutrition and Physical Activity Survey.

Participants: A total of 4487 children aged 2-16 years completed all components of the survey.

Primary and secondary outcome measures: Sodium intake was determined via one 24-hr dietary recall. The population proportion formula was used to identify the major sources of dietary salt. SES was defined by the level of education attained by the primary carer. In addition parental income was used as a secondary indicator of SES.

Results: Dietary sodium intake of children of low SES background was 2576 (SEM 42) mg/d (salt equivalent 6.6 (0.1) g/d) which was greater than children of high SES background 2370 (35) mg/d (salt 6.1 (0.09) g/d) ($P<0.001$). After adjustment for age, gender, energy intake and body mass index, low SES children consumed 195 mg/d (salt 0.5 g/d) more sodium than high SES children ($P<0.001$). Low SES children had a greater intake of sodium from processed meat, gravies/sauces, pastries, breakfast cereals, potatoes and potato snacks (all $P<0.05$).

Conclusion: Australian children from a low SES background have on average a 9% greater intake of sodium from food sources compared to those from a high SES background.

Understanding the socioeconomic patterning of salt intake during childhood should be considered in interventions to reduce cardiovascular disease.

Article summary:

Article focus

- To assess the association between socioeconomic status (SES) and dietary sodium intake in Australian children and adolescents.
- To determine if the major dietary sources of sodium differ by socioeconomic group.

Key messages

- In Australian children socioeconomic status is inversely associated with dietary sodium intake.
- Children of low socioeconomic background consumed more sodium from convenience style foods including pies/sausage rolls; savoury sauces, fried prepared potato; processed meat and potato crisps.

Strengths and limitations of this study

- These results are based on a large nationally representative sample of Australian children and adolescents.
- Sodium intake was determined via a 24-hr dietary recall and therefore does not capture the amount of sodium derived from salt used at the table or during cooking.

The socioeconomic disparity of sodium intake reported in this study is attributable to differences in sodium intake from food sources only. Further research is required to understand how SES impacts on raising sodium intake.

INTRODUCTION

As in adults,[1] dietary sodium intake is positively associated with blood pressure in children.[2, 3] Comparable to other developed nations,[4] dietary sodium intake of Australian children is high and exceeds dietary recommendations.[5, 6] Given blood pressure follows a tracking pattern over the life course,[7, 8] it is likely that high sodium consumption during childhood increases future risk of adult hypertension and subsequent cardiovascular disease (CVD). Increased CVD risk is also observed with low SES, [9, 10] potentially due in part to differences in dietary intakes. Furthermore, prolonged inequalities of SES across the life course are likely to accumulate to overall greater CVD risk, [11, 12] A number of studies in adults[13-15] and in children and adolescents[16-20] have identified SES as a determinant of diet quality. For instance, evidence from cross-sectional studies in children and adolescents have reported a positive association between SES and fruit and vegetable intake[17, 18, 21] and conversely, lower levels of SES have been associated with poor dietary outcomes, including greater intake of high fat foods,[20] fast foods and soft drinks.[19] Studies examining the association between SES and sodium intake are scarce and inconsistent, one study in British adults found low SES was associated with higher intakes of sodium, [22] whereas in US adults there was no association between SES and sodium intake. [23] The aim of this study was to examine the association between SES and dietary sodium intake and the food sources of sodium in a nationally representative sample of Australian children aged 2-16 years.

METHODS

Study design

The 2007 Australian Children's Nutrition and Physical Activity Survey (CNPAS) was a cross-sectional survey designed to collect demographic, dietary, anthropometric and physical activity data from a nationally representative sample of children aged 2-16 years. The full details of the sampling methodology can be found elsewhere.[24] Briefly, participants were recruited using a multistage quota sampling framework. The initial target quota was 1000 participants for each of the following age groups; 2-3, 4-8, 9-13 and 14-16 years (50% boys and 50% girls), to which a 400 booster sample was later provided by the state of South Australia. The primary sampling unit was postcode and clusters of postcodes were randomly selected as stratified by state/territory and by capital city statistical division or rest of state/territory. Randomly selected clusters of postcodes ensured an equal number of participants in each age group, from each of the metro and non-metro areas within each state. Within selected postcodes Random Digit Dialling (RDD) was used to invite eligible households, i.e. those with children aged 2-16 years, to participate in the study. Only one child from each household could participate in the study. The response rate of eligible children was 40%. Due to the non-proportionate nature of the sampling framework each participant was assigned a population weighting which weighted for age, gender and region. The study was approved by the National Health and Medical Research Council registered Ethics Committees of Commonwealth Scientific and Industrial Research Organisation and the University of South Australia. All participants, or where the child was aged <14 years the primary carer, provided written consent.[24]

Assessments

Demographic and food intake data was collected during a face to face computer assisted personal interview (CAPI) completed during February and August 2007. A three-pass 24 h

dietary recall was used to determine all food and beverages consumed from midnight to midnight on the day prior to the interview.[24] The three pass method includes the following stages i) provide a quick list of all foods and beverages ii) a series of probe questions relevant to each quick list item to gather more detailed information on time and place of consumption, any additions to the food item, portion size and brand name iii) finally, a recall review to validate information and make any necessary adjustments. Portion sizes were estimated using a validated food model booklet and standard household measures. To minimise error after data collection all interviews were reviewed by study dietitians to assess for unrealistic portion sizes, inadequate detail and typing errors. The primary carer of participants aged 9 years and under provided information on dietary intake.[24]

Sodium intake was calculated using the Australian nutrient composition database AUSNUT2007, specifically developed by the Food Standards Australia and New Zealand for the CNPAS.[25] A description of the food coding system using in this database has previously been described. [26] Daily sodium (mg) intake was converted to the salt equivalent (g) using the conversion 1 gram of sodium chloride (salt) = 390 mg sodium. Reported salt intake did not include salt added at the table or during cooking.

Indicator of socioeconomic status

Consistent with other dietary studies in children and adolescents we have used level of education attained by the primary carer and household income as markers of SES. [27, 28] The highest level of education attained by the primary carer was used to define SES. Based on this participants were grouped into one of three categories of SES; i) high: includes those

with a university/tertiary qualification ii) mid: includes those with an advanced diploma, diploma or certificate III/IV or trade certificate iii) low: includes those with some or no level of high school education. Parental income was used as a secondary indicator of SES. Reported parental income before tax was grouped into four categories i) AUD$ 0 to $31 999 ii) $31 200 to $51 999 iii) $52 000 to $103 999 iv) ≥ $104 000. Body weight and height were measured using standardised protocols.[29] BMI was calculated as body weight (kg) divided by the square of body height (m^2). Participants were grouped into weight categories (very underweight, underweight, healthy weight, overweight, obese) using the International Obesity Task Force BMI reference cut offs for children.[30, 31]

Statistical analysis

Statistical analyses were completed using STATA/SE 11 (StataCorp, College Station, Texas USA) and PASW Statistics 17.0 (PASW Inc, Chicago, IL, USA). A *P* value of <0.05 was considered significant. All analyses accounted for the complex survey design using the STATA svy command, specifying strata variable (region), cluster variable (post code) and population weighting (age, gender, region). Descriptive statistics are presented as mean (SD) or n (% weighted). To assess the association between SES, as defined by primary carer education level, and sodium intake, multiple regression analysis was used with adjustment for age, gender, energy intake and BMI. To further control for the effects of age, the analysis was repeated stratified by age group (i.e. 2-3; 4-8; 9-13; 14-16 years). These age categories are consistent with those used in Australian dietary guidelines [6]. As income level is sometimes used as a marker of SES [13] the association between parental income and sodium intake was also examined, with adjustment for age, gender, energy intake and BMI. The regression coefficient (β) with 95% CI, corresponding *P* values and the coefficient of determination (R^2) are presented. In a previous analysis[26] which included the same study population we used the population proportion formula[32] to calculate the contribution of sodium from sub-major food group categories, as defined in the CNPAS food group coding system.[24] The population proportion formula [32] is outlined below:

% of sodium from food group = [sum of sodium from food group (mg) / total sum of sodium from all foods (mg)] X 100

For the present study, we have utilised this list which identifies the main sources of dietary sodium, to determine if sodium intake from food group differs between low and high SES categories, based on primary carer education level. To do this, we calculated the mean sodium intake from each sub-major food group by SES category, and compared the mean sodium of low to high SES, using an independent T-test.

RESULTS

Basic characteristics of the 4 487 participants are listed in **Table 1**. As defined by parental education status, the proportion of children from low, mid and high SES background was relatively evenly distributed. Over two thirds of children fell within the two highest income bands. Average daily sodium intake differed by SES (**Figure 1**, P <0.01). Regression analysis indicated that low SES was associated with a 195 mg/d (salt 0.5 g/d) greater intake of sodium. The association between SES and sodium intake remained after adjustment for age, gender, energy intake and BMI (**Table 2**). When stratified by age group the association between sodium intake and SES remained significant between the ages of 4-13 years (**Table**

2), however there was no association between sodium intake and SES in 2-3 year olds or in 14-16 year olds (data not shown). There was no association between sodium intake and parental income (data not shown), however, only 28% of children fell within the two lowest income bands (**Table 1**)

Table 3 lists those sub-major food groups which contributed >1% to the groups' total daily sodium intake. Combined these 23 food groups accounted for 84.5% of total daily sodium intake. Regular breads and bread rolls contributed the most sodium. Moderate sources of sodium, contributing more than 4% of total sodium intake, included mixed dishes where cereal is the major ingredient (e.g. pizza, hamburger, sandwich, savoury rice and noodle based dishes), processed meat, gravies and savoury sauces, pastries, cheese, and breakfast cereals and bars. Compared to children of high SES, children of low SES had a significantly greater intake of sodium from processed meat, gravies and savoury sauce, pastries, breakfast cereals and bars, potatoes and potato snacks (e.g. potato crisps). The percentage difference in sodium intake in each of these categories was 46%, 31%, 24%, 16%, 39% and 46%, respectively **(Table 3).** Conversely, children of high SES background had a significantly greater intake of sodium from the food group containing cakes, buns, muffins, scones, cake-type desserts; and the food group described as batter-based products (e.g. pancakes, picklets). The percentage difference in sodium intake in each of these categories was 16% and 32%, respectively (**Table 3**).

DISCUSSION

In a nationally representative sample of Australian children aged 2-16 years, we found children of low SES background consumed 9% more dietary sodium, from food sources, than those of high SES background. The inverse association between sodium intake and SES was primarily driven by the association in children aged 4-13 years, particularly after adjustment for the important covariates age, gender, energy intake and BMI. In adult studies, low SES has been associated with more frequent consumption of high salt foods, such as soup, sauces, ready to eat meals, savoury seasonings, sausages and potato.[33, 34] Given parental control over children's food choices during these years, it is likely that SES disparities in adult food choices relating to high salt foods may filter down into children's eating practices. We found no association between SES and sodium intake in 2-3 and 14-16 year olds. Although some evidence indicates SES disparities in dietary patterns may be present during infancy,[35] it is possible such early differences are not seen in dietary patterns with the restricted range of food types. In the case of adolescents, as autonomy over food choices increases, other factors, such as peer-influence, taste and eating away from the home[36] may become more prominent determinants of dietary intake.

Using US National Health and Nutrition Examination Survey (NHANES) data, Mazur et al.[37] explored the association of SES, as indicated by head of household education status and household income, on sodium intake in Hispanic children aged 4-16 years. Interestingly, in this study lower levels of education were associated with lower sodium intake[37]. This is contrary to our own findings as well as past studies, which generally link lower SES to overall poorer dietary outcomes.[13] We found no association between sodium intake and level of income, however low income bands were underrepresented. This is in contrast to the findings in Hispanic children, where low household income was associated with a greater intake of dietary sodium.[37] In a New Zealand food survey, low cost 'home brand' labelled food products were found to contain greater quantities of sodium than the more expensive branded food products.[38] The impact of income on sodium intake in Australian children remains unclear and further research is required.

Previous studies in children have reported socioeconomic differences in the consumption of certain food groups.[39, 40] For example, in European children of low SES background, greater intake of starchy foods, meat products, savoury snacks such as hamburgers, sugar and confectionary, pizza, desserts and soft drinks have been reported.[39, 40] In the present study those food groups which were found to contribute more sodium to the diets of low SES children tended to include convenience style foods (i.e. pies/sausage rolls; savoury sauce and casserole base sauces; fried prepared potato; processed meat; potato snacks). Comparably, children of high SES background consumed greater amounts of sodium from cake and baked type products. However, a significant amount of sodium in baked products can be in sodium bicarbonate rather than in the form of sodium chloride. Sodium bicarbonate, unlike sodium chloride, has not been directly associated with adverse blood pressure outcomes.[41]

With reference to sodium intake data by age group[5] and comparison to the recommended daily Upper Limit of sodium[6] it is evident that Australian children of all ages across all SES backgrounds are consuming too much dietary sodium. However, for the first time our findings indicate that socioeconomic disparities exist in sodium intake in Australian children aged 9-13 years. To reduce sodium intake in children a comprehensive approach is required, firstly targeting food policy, to encourage product reformulation of lower sodium food products across all price ranges within the food supply. Secondly, consumer education and awareness campaigns, that encourage food choices which are based on fresh products with minimal processing; this may require strategies that equip parents with enhanced food preparation skills and knowledge of the 'hidden' salt added to many commonly eaten processed foods. Furthermore, it is apparent that these strategies need to reach lower SES groups.

The major strengths of this study include the use of a large nationally-representative sample of Australian children, with comprehensive and standardised collection of dietary intake. Limitations of the study include the use of a 24-hr dietary recall to assess sodium intake. Firstly, this method fails to capture the amount of salt coming from salt added at the table and during cooking and therefore is likely to underestimate the true value of salt intake.(42) The majority (77%) of dietary sodium consumed is from salt added to processed foods, whilst a smaller amount (11%) has been found to be derived from salt added at the table and during cooking.(43) In the present study, the higher intake of sodium reported in children from low SES background is attributable to differences in sodium intake from food sources only. In a previous analysis of these data, we found that children from low SES background (33%) were more likely to report adding salt at the table than children from high SES (25%).(26) Thus, it is likely that children of low SES background are consuming greater amounts of total daily sodium than reported in the present analysis. Secondly, assessment of sodium intake is limited by the quality of food composition databases, which may not capture the variation in sodium content of different brand products within each food group. (42, 44)

In summary, the findings of higher salt intakes from food sources in children of lower SES background, within in a nationally representative sample, provides focus for concern regarding salt related disease across the life course. This socioeconomic patterning of salt intake may in turn influence the SES disparity seen in hypertension and cardiovascular risk in adulthood. To reduce socioeconomic inequalities in health, interventions need to begin early in life and should include product reformulation of lower sodium food products across all price ranges, as well as consumer education and awareness campaigns which reach low SES groups.

Contributorship statement: The author's responsibilities were as follows – CAG, KJC, LJR and CAN designed research; CAG performed statistical analysis and wrote the manuscript and is guarantor of the paper; LJR, KJC and CAN helped with data interpretation, revision of manuscript and provided significant consultation. All authors have read and approved the final manuscript.

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Table 1. Basic characteristics of Australian children and adolescents aged 2-16 years (n 4 487)

Characteristic	**n or mean**	**% or SD**
Male (n %)	2 249	51
Age (years) (mean SD)	9.1	4.3
Age group (n %)		
2-3 years	1071	12
4-8 years	1216	34
9-13 years	1110	33
14-16 years	1090	21
Socioeconomic status (n %)*		
Low SES	1414	30
Mid SES	1583	36
High SES	1490	34
Parental income (n %)†		
$0 to 31 999	500	11
$32 000 to 51 999	732	17
$52 000 to 103 999	1850	42
$≥104 000	1169	30
Weight status (n %)‡		
Underweight	212	5
Healthy weight	3267	72
Overweight	761	17
Obese	247	6
Energy (kJ/d) (mean SD)	8392	3156
Sodium (mg/d) (mean SD)	2473	1243
Salt equivalent (g/d) (mean SD)§	6.3	3.1

 SES as defined by the highest level of education attained by the primary carer

†Participants with missing information for parental income (n=236) excluded

‡Weight classification based on the International Obesity Task Force BMI reference cut offs (30, 31)

§Salt equivalents (i.e. sodium chloride: 1 g = 390 mg sodium)

Figure 1. Mean sodium intake (mg/d) by socioeconomic group (n = 4487)†

[JPEG IMAGE ATTACHED]

* Significantly different from high SES (*P* <0.001)

** Significantly different from high SES (*P* <0.05)

†SES as defined by the highest level of education attained by the primary carer

Table 2. Association between socioeconomic status (SES) and dietary sodium intake (390 mg/d) (1 g/d salt) in Australian children and adolescents aged 2-16 years (n 4 487) ▯ †

Variable	**Total Sample (n=4 487)**		**Age group‡**			
			4-8 years (n=1 216)		**9-13 years (n=1 110)**	
	β (95% CI)	**P Value**	**β (95% CI)**	**P Value**	**β (95% CI)**	**P Value**
Unadjusted						
High SES (reference)						
Mid SES	0.3 (0.03, 0.5)	0.03	0.2 (-0.1, 0.6)	0.17	0.2 (-0.2, 0.6)	0.319
Low SES	0.5 (0.3, 0.8)	<0.001	0.5 (0.1, 1.0)	0.02	0.5 (-0.02, 1.0)	0.06
	R^2=0.004	<0.01	R^2=0.008	0.05	R^2=0.004	0.16
Adjusted§						

High SES (reference)						
Mid SES	0.2 (0.01, 0.4)	0.04	0.2 (-0.1, 0.4)	0.13	0.2 (-0.2, 0.6)	0.23
Low SES	0.5 (0.2, 0.7)	<0.001	0.6 (0.2, 0.9)	0.001	0.6 (0.1, 1.0)	0.01
	R^2=0.49	<0.001	R^2=0.37	<0.001	R^2=0.36	<0.001

 Dependent variable is sodium intake in units of 390 mg/d (salt equivalent 1 g/d) and independent variable is SES entered as an indicator variable: high SES is the reference category

†SES as defined by the highest level of education attained by the primary carer

‡No association between salt intake and SES in age groups 2-3 years and 14-16 years (models not shown)

§Adjusted for gender, age, energy intake and BMI

Table 3. Dietary sources of sodium intake listed by their contribution to intake for the group and mean daily sodium intake by food group, by socioeconomic group

Food group	Total sample (n 4487)	SES Group†			
		Low (n 1414)	Mid (n 1583)	High (n 1490)	P value‡
	% contribution to total daily sodium intake	Mean sodium (SD) mg/d	Mean sodium (SD) mg/d	Mean sodium (SD) mg/d	
Regular breads and bread rolls	13.4	340 (315)	330 (300)	324 (317)	0.26
Mixed dishes where cereal is the major ingredient	8.7	214 (514)	256 (616)	172 (445)	0.07
Processed meat§	**7.6**	**216 (464)**	**180 (403)**	**168 (368)**	**0.02**
Gravies and savoury sauces	**6.5**	**182 (385)**	**166 (395)**	**139 (354)**	**0.01**
Pastries¶	**4.9**	**135 (400)**	**120 (352)**	**109 (345)**	**0.03**

Cheese	4.6	114 (209)	110 (190)	116 (186)	0.80
Breakfast cereals and bars	**4.2**	**113 (176)**	**101 (166)**	**97 (161)**	**0.03**
Dairy milk	3.9	95 (106)	94 (103)	100 (98)	0.25
Herbs, spices, seasonings and stock cubes	3.7	114 (482)	75 (246)	90 (301)	0.31
Sausages, frankfurts and saveloys	2.9	79 (259)	74 (136)	61 (201)	0.07
Mixed dishes where poultry/game is the major component	2.6	79 (268)	59 (194)	60 (238)	0.09
Soup (prepared, ready to eat)	2.6	51 (288)	74 (379)	65 (282)	0.25
English-style muffins, flat breads, and savoury sweet breads	2.4	55 (158)	58 (180)	67 (181)	0.17
Cakes, buns, muffins, scones,	**2.3**	**54 (153)**	**52 (144)**	**68 (176)**	**0.02**

cake-type desserts					
Savoury biscuits	2.2	49 (136)	57 (147)	57 (152)	0.34
Yeast, yeast, vegetable and meat extracts	2.0	47 (117)	55 (143)	45 (108)	0.70
Potatoes	**1.9**	**53 (128)**	**51 (127)**	**38 (106)**	**0.01**
Batter-based products††	**1.7**	**38 (161)**	**37 (150)**	**50 (180)**	**0.05**
Potato snacks	**1.7**	**51 (149)**	**40 (121)**	**35 (125)**	**0.03**
Pasta and pasta products	1.4	35 (142)	32 (130)	35 (138)	0.89
Sweet biscuits	1.2	29 (64)	33 (72)	27 (62)	0.61
Mixed dishes where beef, veal or lamb is the major component	1.1	32 (175)	21 (116)	28 (56)	0.53
Mature legumes and pulse	1.0	21 (149)	21 (137)	35 (258)	0.12

products and dishes

 Includes those sub-major food group categories that contribute >1.0% of sodium to daily intake ambiguous

†SES as defined by the highest level of education attained by the primary carer

‡Means are compared between low and high SES groups using independent T-test

§includes ham, bacon and processed delicatessen meat

includes pasta sauces and casserole bases

¶includes pies and sausage rolls

  includes potato gems and wedges

††includes pancakes and pikelets

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~~Dietary sodium intake is associated with socioeconomic status in Australian children: a cross-sectional study~~

Is socioeconomic status associated with dietary sodium intake in Australian children? A cross-sectional study

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Data sharing statement:

The authors declare that on request all data files are available for analysis from the corresponding author at carley.grimes@deakin.edu.au

ABSTRACT

Objective: To assess the association between socioeconomic status (SES) and dietary sodium intake, and identify if the major dietary sources of sodium differ by socioeconomic group in a nationally representative sample of Australian children.

Design: Cross-sectional survey.

Setting: 2007 Australian National Children's Nutrition and Physical Activity Survey.

Participants: A total of 4487 children aged 2-16 years completed all components of the survey.

Primary and secondary outcome measures: Sodium intake was determined via one 24-hr dietary recall. The population proportion formula was used to identify the major sources of dietary salt. SES was defined by the level of education attained by the primary carer. In addition parental income was used as a secondary indicator of SES.

Results: Dietary sodium intake of children of low SES background was 2576 (SEM 42) mg/d (salt equivalent 6.6 (0.1) g/d) which was greater than children of high SES background 2370 (35) mg/d (salt 6.1 (0.09) g/d) ($P<0.001$). After adjustment for age, gender, energy intake and body mass index, low SES children consumed 195 mg/d (salt 0.5 g/d) more sodium than high SES children ($P<0.001$). Low SES children had a greater intake of sodium from processed meat, gravies/sauces, pastries, breakfast cereals, potatoes and potato snacks (all $P<0.05$).

Conclusion: Australian children from a low SES background have on average a 9% greater intake of sodium from food sources compared to those from a high SES background. ~~This socioeconomic patterning of salt intake may in turn influence the SES disparity seen in~~

hypertension and cardiovascular risk in adulthood. Understanding these the differences in socioeconomic patterning of salt intake during childhood risk provides important focus for intervention should be considered in interventions to reduce cardiovascular disease.

Article summary:

Article focus

- To assess the association between socioeconomic status (SES) and dietary sodium intake in Australian children and adolescents.
- To determine if the major dietary sources of sodium differ by socioeconomic group.

Key messages

- In Australian children socioeconomic status is inversely associated with dietary sodium intake.
- Children of low socioeconomic background consumed more sodium from convenience style foods including pies/sausage rolls; savoury sauces, fried prepared potato; processed meat and potato crisps.

Strengths and limitations of this study

- These results are based on a large nationally representative sample of Australian children and adolescents.
- Sodium intake was determined via a 24-hr dietary recall and therefore does not capture the amount of sodium derived from salt used at the table or during cooking.
- The socioeconomic disparity of sodium intake reported in this study is attributable to differences in sodium intake from food sources only. Further research is required to understand how SES impacts on raising sodium intake. ~~on total daily sodium intake.~~

INTRODUCTION

As in adults,[1] dietary sodium intake is positively associated with blood pressure in children.[2, 3] Comparable to other developed nations,[4] dietary sodium intake of Australian children is high and exceeds dietary recommendations.[5, 6] Given blood pressure follows a tracking pattern over the life course,[7, 8] it is likely that high sodium consumption during childhood increases future risk of adult hypertension and subsequent cardiovascular disease (CVD). Increased CVD risk is also observed with low SES, [9, 10] potentially due in part to differences in dietary intakes. Furthermore, prolonged inequalities of SES across the life course are likely to accumulate to overall greater CVD risk, [11, 12] A number of studies in adults[13-15] and in children and adolescents[16-20] have identified SES as a determinant of diet quality. For instance, evidence from cross-sectional studies in children and adolescents have reported a positive association between SES and fruit and vegetable intake[17, 18, 21] and conversely, lower levels of SES have been associated with poor dietary outcomes, including greater intake of high fat foods,[20] fast foods and soft drinks.[19] Studies examining the association between SES and sodium intake are scarce and inconsistent, one study in British adults found low SES was associated with higher intakes of sodium, [22] whereas in US adults there was no association between SES and sodium intake. [23] The aim of this study was to examine the association between SES and dietary sodium intake and the food sources of sodium in a nationally representative sample of Australian children aged 2-16 years.

METHODS

Study design

The 2007 Australian Children's Nutrition and Physical Activity Survey (CNPAS) was a cross-sectional survey designed to collect demographic, dietary, anthropometric and physical activity data from a nationally representative sample of children aged 2-16 years. The full details of the sampling methodology can be found elsewhere.[24] Briefly, participants were recruited using a multistage quota sampling framework. The initial target quota was 1000 participants for each of the following age groups; 2-3, 4-8, 9-13 and 14-16 years (50% boys and 50% girls), to which a 400 booster sample was later provided by the state of South Australia. The primary sampling unit was postcode and clusters of postcodes were randomly selected as stratified by state/territory and by capital city statistical division or rest of state/territory. Randomly selected clusters of postcodes ensured an equal number of participants in each age group, from each of the metro and non-metro areas within each state. Within selected postcodes Random Digit Dialling (RDD) was used to invite eligible households, i.e. those with children aged 2-16 years, to participate in the study. Only one child from each household could participate in the study. The response rate of eligible children was 40%. Due to the non-proportionate nature of the sampling framework each participant was assigned a population weighting which weighted for age, gender and region. The study was approved by the National Health and Medical Research Council registered Ethics Committees of Commonwealth Scientific and Industrial Research Organisation and the University of South Australia. All participants, or where the child was aged <14 years the primary carer, provided written consent.[24]

Assessments

Demographic and food intake data was collected during a face to face computer assisted personal interview (CAPI) completed during February and August 2007. A three-pass 24 h

dietary recall was used to determine all food and beverages consumed from midnight to midnight on the day prior to the interview.[24] The three pass method includes the following stages i) provide a quick list of all foods and beverages ii) a series of probe questions relevant to each quick list item to gather more detailed information on time and place of consumption, any additions to the food item, portion size and brand name iii) finally, a recall review to validate information and make any necessary adjustments. Portion sizes were estimated using a validated food model booklet and standard household measures. To minimise error after data collection all interviews were reviewed by study dietitians to assess for unrealistic portion sizes, inadequate detail and typing errors. The primary carer of participants aged 9 years and under provided information on dietary intake.[24]

Sodium intake was calculated using the Australian nutrient composition database AUSNUT2007, specifically developed by the Food Standards Australia and New Zealand for the CNPAS.[25] A description of the food coding system using in this database has previously been described.[26] Daily sodium (mg) intake was converted to the salt equivalent (g) using the conversion 1 gram of sodium chloride (salt) = 390 mg sodium. Reported salt intake did not include salt added at the table or during cooking.

Indicator of socioeconomic status

Consistent with other dietary studies in children and adolescents we have used level of education attained by the primary carer and household income as markers of SES.[27, 28] The highest level of education attained by the primary carer was used to define SES. Based on this participants were grouped into one of three categories of SES; i) high: includes those

with a university/tertiary qualification ii) mid: includes those with an advanced diploma, diploma or certificate III/IV or trade certificate iii) low: includes those with some or no level of high school education. Parental income was used as a secondary indicator of SES. Reported parental income before tax was grouped into four categories i) AUD$ 0 to $31 999 ii) $31 200 to $51 999 iii) $52 000 to $103 999 iv) ≥ $104 000. Body weight and height were measured using standardised protocols.[29] BMI was calculated as body weight (kg) divided by the square of body height (m^2). Participants were grouped into weight categories (very underweight, underweight, healthy weight, overweight, obese) using the International Obesity Task Force BMI reference cut offs for children.[30, 31]

Statistical analysis

Statistical analyses were completed using STATA/SE 11 (StataCorp, College Station, Texas USA) and PASW Statistics 17.0 (PASW Inc, Chicago, IL, USA). A *P* value of <0.05 was considered significant. All analyses accounted for the complex survey design using the STATA svy command, specifying strata variable (region), cluster variable (post code) and population weighting (age, gender, region). Descriptive statistics are presented as mean (SD) or n (% weighted). To assess the association between SES, as defined by primary carer education level, and sodium intake, multiple regression analysis was used with adjustment for age, gender, energy intake and BMI. To further control for the effects of age, the analysis was repeated stratified by age group (i.e. 2-3; 4-8; 9-13; 14-16 years). These age categories are consistent with those used in Australian dietary guidelines [6]. As income level is sometimes used as a marker of SES [13] the association between parental income and sodium intake was also examined, with adjustment for age, gender, energy intake and BMI. The regression coefficient (β) with 95% CI, corresponding *P* values and the coefficient of determination (R^2) are presented. In a previous analysis[26] which included the same study population we used the population proportion formula[32] to calculate the contribution of sodium from sub-major food group categories, as defined in the CNPAS food group coding system.[24] The population proportion formula [32] is outlined below:

% of sodium from food group = [sum of sodium from food group (mg) / total sum of sodium from all foods (mg)] X 100

For the present study, we have utilised this list which identifies the main sources of dietary sodium, to determine if sodium intake from food group differs between low and high SES categories, based on primary carer education level. To do this, we calculated the mean sodium intake from each sub-major food group by SES category, and compared the mean sodium of low to high SES, using an independent T-test.

RESULTS

Basic characteristics of the 4 487 participants are listed in **Table 1**. As defined by parental education status, the proportion of children from low, mid and high SES background was relatively evenly distributed. Over two thirds of children fell within the two highest income bands. Average daily sodium intake differed by SES (**Figure 1**, P <0.01). Regression analysis indicated that low SES was associated with a 195 mg/d (salt 0.5 g/d) greater intake of sodium. The association between SES and sodium intake remained after adjustment for age, gender, energy intake and BMI (**Table 2**). When stratified by age group the association between sodium intake and SES remained significant between the ages of 4-13 years (**Table**

2), however there was no association between sodium intake and SES in 2-3 year olds or in 14-16 year olds (data not shown). There was no association between sodium intake and parental income (data not shown), however, only 28% of children fell within the two lowest income bands (**Table 1**)

Table 3 lists those sub-major food groups which contributed >1% to the groups' total daily sodium intake. Combined these 23 food groups accounted for 84.5% of total daily sodium intake. Regular breads and bread rolls contributed the most sodium. Moderate sources of sodium, contributing more than 4% of total sodium intake, included mixed dishes where cereal is the major ingredient (e.g. pizza, hamburger, sandwich, savoury rice and noodle based dishes), processed meat, gravies and savoury sauces, pastries, cheese, and breakfast cereals and bars. Compared to children of high SES, children of low SES had a significantly greater intake of sodium from processed meat, gravies and savoury sauce, pastries, breakfast cereals and bars, potatoes and potato snacks (e.g. potato crisps). The percentage difference in sodium intake in each of these categories was 46%, 31%, 24%, 16%, 39% and 46%, respectively **(Table 3).** Conversely, children of high SES background had a significantly greater intake of sodium from the food group containing cakes, buns, muffins, scones, cake-type desserts; and the food group described as batter-based products (e.g. pancakes, picklets). The percentage difference in sodium intake in each of these categories was 16% and 32%, respectively (**Table 3**).

DISCUSSION

In a nationally representative sample of Australian children aged 2-16 years, we found children of low SES background consumed 9% more dietary sodium, from food sources, than those of high SES background. The inverse association between sodium intake and SES was primarily driven by the association in children aged 4-13 years, particularly after adjustment for the important covariates age, gender, energy intake and BMI. In adult studies, low SES has been associated with more frequent consumption of high salt foods, such as soup, sauces, ready to eat meals, savoury seasonings, sausages and potato.[33, 34] Given parental control over children's food choices during these years, it is likely that SES disparities in adult food choices relating to high salt foods may filter down into children's eating practices. We found no association between SES and sodium intake in 2-3 and 14-16 year olds. Although some evidence indicates SES disparities in dietary patterns may be present during infancy,[35] it is possible such early differences are not seen in dietary patterns with the restricted range of food types. In the case of adolescents, as autonomy over food choices increases, other factors, such as peer-influence, taste and eating away from the home[36] may become more prominent determinants of dietary intake.

Using US National Health and Nutrition Examination Survey (NHANES) data, Mazur et al.[37] explored the association of SES, as indicated by head of household education status and household income, on sodium intake in Hispanic children aged 4-16 years. Interestingly, in this study lower levels of education were associated with lower sodium intake[37]. This is contrary to our own findings as well as past studies, which generally link lower SES to overall poorer dietary outcomes.[13] We found no association between sodium intake and level of income, however low income bands were underrepresented. This is in contrast to the findings in Hispanic children, where low household income was associated with a greater intake of dietary sodium.(37) In a New Zealand food survey, low cost 'home brand' labelled food products were found to contain greater quantities of sodium than the more expensive branded food products.(38) The impact of income on sodium intake in Australian children remains unclear and further research is required.

Previous studies in children have reported socioeconomic differences in the consumption of certain food groups.(39, 40) For example, in European children of low SES background, greater intake of starchy foods, meat products, savoury snacks such as hamburgers, sugar and confectionary, pizza, desserts and soft drinks have been reported.(39, 40) In the present study those food groups which were found to contribute more sodium to the diets of low SES children tended to include convenience style foods (i.e. pies/sausage rolls; savoury sauce and casserole base sauces; fried prepared potato; processed meat; potato snacks). Comparably, children of high SES background consumed greater amounts of sodium from cake and baked type products. However, a significant amount of sodium in baked products can be in sodium bicarbonate rather than in the form of sodium chloride. Sodium bicarbonate, unlike sodium chloride, has not been directly associated with adverse blood pressure outcomes.(41)

With reference to sodium intake data by age group(5) and comparison to the recommended daily Upper Limit of sodium(6) it is evident that Australian children of all ages across all SES backgrounds are consuming too much dietary sodium. However, for the first time our findings indicate that socioeconomic disparities exist in sodium intake in Australian children aged 9-13 years. To reduce sodium intake in children a comprehensive approach is required, firstly targeting food policy, to encourage product reformulation of lower sodium food products across all price ranges within the food supply. Secondly, consumer education and awareness campaigns, that encourage food choices which are based on fresh products with minimal processing; this may require strategies that equip parents with enhanced food preparation skills and knowledge of the 'hidden' salt added to many commonly eaten processed foods. Furthermore, it is apparent that these strategies need to reach lower SES groups.

The major strengths of this study include the use of a large nationally-representative sample of Australian children, with comprehensive and standardised collection of dietary intake. Limitations of the study include the use of a 24-hr dietary recall to assess sodium intake. Firstly, this method ~~which~~ fails to capture the amount of salt coming from salt added at the table and during cooking and therefore is likely to underestimate the true value of salt intake.[42] The majority (77%) of dietary sodium consumed is from salt added to processed foods, whilst a smaller amount (11%) has been found to be derived from salt added at the table and during cooking.[43] In the present study, the higher intake of sodium reported in children from low SES background is attributable to differences in sodium intake from food sources only. In a previous analysis of these ~~is~~ data, we found that children from low SES background (33~~25~~%) were more likely to report adding salt at the table than children from high SES (25~~33~~%).[26] Thus, it is likely that children of low SES background are consuming greater amounts of total daily sodium than reported in the present analysis. Secondly, assessment of sodium intake is limited by the quality of food composition databases, which may not capture the variation in sodium content of different brand products within each food group.[42, 44]

In summary, the findings of higher salt intakes from food sources in children of lower SES background, within in a nationally representative sample, provides focus for concern regarding salt related disease across the life course. This socioeconomic patterning of salt intake may in turn influence the SES disparity seen in hypertension and cardiovascular risk in adulthood. To reduce socioeconomic inequalities in health, interventions need to begin early in life and should include product reformulation of lower sodium food products across all price ranges, as well as consumer education and awareness campaigns which reach low SES groups.

Contributorship statement: The author's responsibilities were as follows – CAG, KJC, LJR and CAN designed research; CAG performed statistical analysis and wrote the manuscript and is guarantor of the paper; LJR, KJC and CAN helped with data interpretation, revision of manuscript and provided significant consultation. All authors have read and approved the final manuscript.

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Table 1. Basic characteristics of Australian children and adolescents aged 2-16 years (n 4 487)

Characteristic	**n or mean**	**% or SD**
Male (n %)	2 249	51
Age (years) (mean SD)	9.1	4.3
Age group (n %)		
2-3 years	1071	12
4-8 years	1216	34
9-13 years	1110	33
14-16 years	1090	21
Socioeconomic status (n %)*		
Low SES	1414	30
Mid SES	1583	36
High SES	1490	34
Parental income (n %)†		
$0 to 31 999	500	11
$32 000 to 51 999	732	17
$52 000 to 103 999	1850	42
$≥104 000	1169	30
Weight status (n %)‡		
Underweight	212	5
Healthy weight	3267	72
Overweight	761	17
Obese	247	6
Energy (kJ/d) (mean SD)	8392	3156
Sodium (mg/d) (mean SD)	2473	1243
Salt equivalent (g/d) (mean SD)§	6.3	3.1

* SES as defined by the highest level of education attained by the primary carer

†Participants with missing information for parental income (n=236) excluded

‡Weight classification based on the International Obesity Task Force BMI reference cut offs (30, 31)

§Salt equivalents (i.e. sodium chloride: 1 g = 390 mg sodium)

Figure 1. Mean sodium intake (mg/d) by socioeconomic group (n = 4487)†

[JPEG IMAGE ATTACHED]

* Significantly different from high SES (*P* <0.001)

** Significantly different from high SES (*P* <0.05)

†SES as defined by the highest level of education attained by the primary carer

Table 2. Association between socioeconomic status (SES) and dietary sodium intake (390 mg/d) (1 g/d salt) in Australian children and adolescents aged 2-16 years (n 4 487) ▯ †

Variable	Total Sample (n=4 487)		Age group‡			
			4-8 years (n=1 216)		9-13 years (n=1 110)	
	β (95% CI)	P Value	β (95% CI)	P Value	β (95% CI)	P Value
Unadjusted						
High SES (reference)						
Mid SES	0.3 (0.03, 0.5)	0.03	0.2 (-0.1, 0.6)	0.17	0.2 (-0.2, 0.6)	0.319
Low SES	0.5 (0.3, 0.8)	<0.001	0.5 (0.1, 1.0)	0.02	0.5 (-0.02, 1.0)	0.06
	R^2=0.004	<0.01	R^2=0.008	0.05	R^2=0.004	0.16
Adjusted§						

High SES (reference)						
Mid SES	0.2 (0.01, 0.4)	0.04	0.2 (-0.1, 0.4)	0.13	0.2 (-0.2, 0.6)	0.23
Low SES	0.5 (0.2, 0.7)	<0.001	0.6 (0.2, 0.9)	0.001	0.6 (0.1, 1.0)	0.01
	R^2=0.49	<0.001	R^2=0.37	<0.001	R^2=0.36	<0.001

▯ Dependent variable is sodium intake in units of 390 mg/d (salt equivalent 1 g/d) and independent variable is SES entered as an indicator variable: high SES is the reference category

†SES as defined by the highest level of education attained by the primary carer

‡No association between salt intake and SES in age groups 2-3 years and 14-16 years (models not shown)

§Adjusted for gender, age, energy intake and BMI

Table 3. Dietary sources of sodium intake listed by their contribution to intake for the group and mean daily sodium intake by food group, by socioeconomic group

Food group	Total sample (n 4487)	SES Group†			
		Low (n 1414)	Mid (n 1583)	High (n 1490)	P value‡
	% contribution to total daily sodium intake	Mean sodium (SD) mg/d	Mean sodium (SD) mg/d	Mean sodium (SD) mg/d	
Regular breads and bread rolls	13.4	340 (315)	330 (300)	324 (317)	0.26
Mixed dishes where cereal is the major ingredient	8.7	214 (514)	256 (616)	172 (445)	0.07
Processed meat§	**7.6**	**216 (464)**	**180 (403)**	**168 (368)**	**0.02**
Gravies and savoury sauces	**6.5**	**182 (385)**	**166 (395)**	**139 (354)**	**0.01**
Pastries¶	**4.9**	**135 (400)**	**120 (352)**	**109 (345)**	**0.03**

Cheese	4.6	114 (209)	110 (190)	116 (186)	0.80
Breakfast cereals and bars	**4.2**	**113 (176)**	**101 (166)**	**97 (161)**	**0.03**
Dairy milk	3.9	95 (106)	94 (103)	100 (98)	0.25
Herbs, spices, seasonings and stock cubes	3.7	114 (482)	75 (246)	90 (301)	0.31
Sausages, frankfurts and saveloys	2.9	79 (259)	74 (136)	61 (201)	0.07
Mixed dishes where poultry/game is the major component	2.6	79 (268)	59 (194)	60 (238)	0.09
Soup (prepared, ready to eat)	2.6	51 (288)	74 (379)	65 (282)	0.25
English-style muffins, flat breads, and savoury sweet breads	2.4	55 (158)	58 (180)	67 (181)	0.17
Cakes, buns, muffins, scones,	**2.3**	**54 (153)**	**52 (144)**	**68 (176)**	**0.02**

cake-type desserts					
Savoury biscuits	2.2	49 (136)	57 (147)	57 (152)	0.34
Yeast, yeast, vegetable and meat extracts	2.0	47 (117)	55 (143)	45 (108)	0.70
Potatoes▯ ▯ ▯ ▯	**1.9**	**53 (128)**	**51 (127)**	**38 (106)**	**0.01**
Batter-based products††	**1.7**	**38 (161)**	**37 (150)**	**50 (180)**	**0.05**
Potato snacks	**1.7**	**51 (149)**	**40 (121)**	**35 (125)**	**0.03**
Pasta and pasta products	1.4	35 (142)	32 (130)	35 (138)	0.89
Sweet biscuits	1.2	29 (64)	33 (72)	27 (62)	0.61
Mixed dishes where beef, veal or lamb is the major component	1.1	32 (175)	21 (116)	28 (56)	0.53
Mature legumes and pulse	1.0	21 (149)	21 (137)	35 (258)	0.12

products and dishes

 Includes those sub-major food group categories that contribute >1.0% of sodium to daily intake ambiguous

†SES as defined by the highest level of education attained by the primary carer

‡Means are compared between low and high SES groups using independent T-test

§includes ham, bacon and processed delicatessen meat

includes pasta sauces and casserole bases

¶includes pies and sausage rolls

  includes potato gems and wedges

††includes pancakes and pikelets

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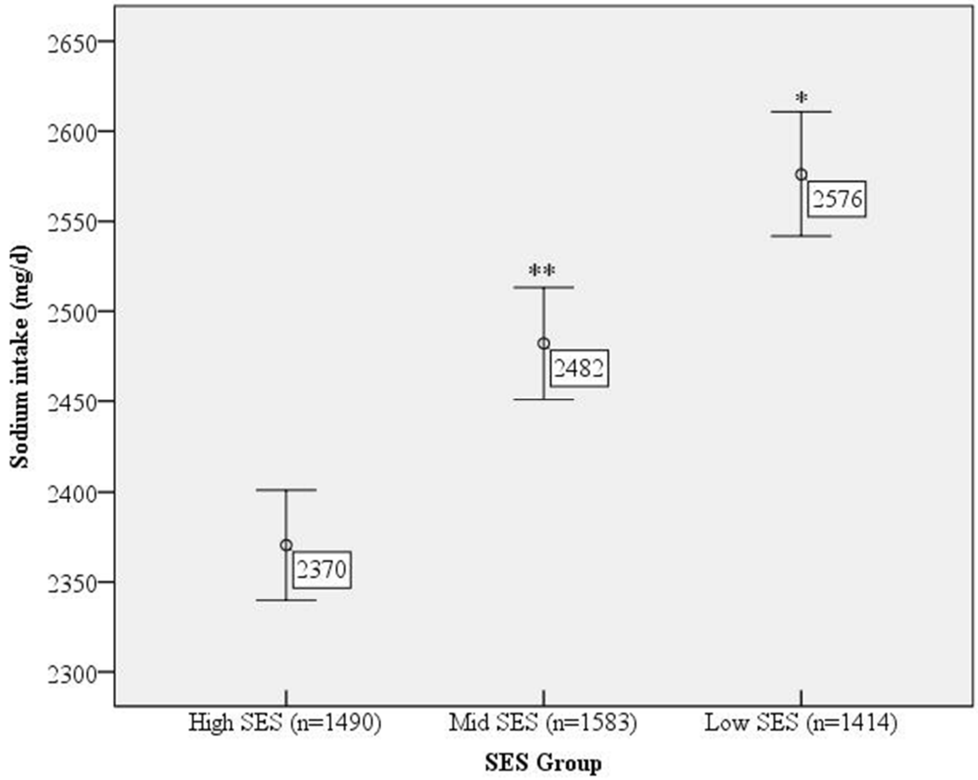

* Significantly different from high SES (P <0.001)
** Significantly different from high SES (P <0.05)
†SES as defined by the highest level of education attained by the primary carer
220x176mm (72 x 72 DPI)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Is socioeconomic status associated with dietary sodium intake in Australian children? A cross-sectional study

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Is socioeconomic status associated with dietary sodium intake in Australian children? A cross-sectional study

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Key words:

Sodium, Dietary; Sodium Chloride; Socioeconomic Status; Child; Australia

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Declaration of competing interests:

All authors have completed the Unified Competing Interest form atwww.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare: Carley Grimes had financial support in the form of a post graduate scholarship from the Heart Foundation, Australia for the submitted work; and had no financial relationships with any organisations that might have an interest in the submitted work in the previous three years, no other relationships or activities that could appear to have influenced the submitted work. Karen Campbell had no support from any organisation for the submitted work; no other relationships or activities that could appear to have influenced the submitted work. Caryl Nowson has received research funds from Meat & Livestock Australia; National Health and Medical Research Council, Wicking Foundation, National Heart Foundation, Australia, Helen MacPerhson Smith Trust and Red Cross Blood Bank. These payments are unrelated to the submitted work. Lynn Riddell has received research funds from Meat & Livestock Australia. These payments are unrelated to the submitted work.

Data sharing statement:

The authors declare that on request all data files are available for analysis from the corresponding author at carley.grimes@deakin.edu.au

ABSTRACT

Objective: To assess the association between socioeconomic status (SES) and dietary sodium intake, and identify if the major dietary sources of sodium differ by socioeconomic group in a nationally representative sample of Australian children.

Design: Cross-sectional survey.

Setting: 2007 Australian National Children's Nutrition and Physical Activity Survey.

Participants: A total of 4487 children aged 2-16 years completed all components of the survey.

Primary and secondary outcome measures: Sodium intake was determined via one 24-hr dietary recall. The population proportion formula was used to identify the major sources of dietary salt. SES was defined by the level of education attained by the primary carer. In addition parental income was used as a secondary indicator of SES.

Results: Dietary sodium intake of children of low SES background was 2576 (SEM 42) mg/d (salt equivalent 6.6 (0.1) g/d) which was greater than children of high SES background 2370 (35) mg/d (salt 6.1 (0.09) g/d) ($P<0.001$). After adjustment for age, gender, energy intake and body mass index, low SES children consumed 195 mg/d (salt 0.5 g/d) more sodium than high SES children ($P<0.001$). Low SES children had a greater intake of sodium from processed meat, gravies/sauces, pastries, breakfast cereals, potatoes and potato snacks (all $P<0.05$).

Conclusion: Australian children from a low SES background have on average a 9% greater intake of sodium from food sources compared to those from a high SES background.

Understanding the socioeconomic patterning of salt intake during childhood should be considered in interventions to reduce cardiovascular disease.

Article summary:

Article focus

- To assess the association between socioeconomic status (SES) and dietary sodium intake in Australian children and adolescents.
- To determine if the major dietary sources of sodium differ by socioeconomic group.

Key messages

- In Australian children socioeconomic status is inversely associated with dietary sodium intake.
- Children of low socioeconomic background consumed more sodium from convenience style foods including pies/sausage rolls; savoury sauces, fried prepared potato; processed meat and potato crisps.

Strengths and limitations of this study

- These results are based on a large nationally representative sample of Australian children and adolescents.
- Sodium intake was determined via a 24-hr dietary recall and therefore does not capture the amount of sodium derived from salt used at the table or during cooking.

The socioeconomic disparity of sodium intake reported in this study is attributable to differences in sodium intake from food sources only. Further research is required to understand how SES impacts on raising sodium intake.

INTRODUCTION

As in adults,[1] dietary sodium intake is positively associated with blood pressure in children.[2, 3] Comparable to other developed nations,[4] dietary sodium intake of Australian children is high and exceeds dietary recommendations.[5, 6] Given blood pressure follows a tracking pattern over the life course,[7, 8] it is likely that high sodium consumption during childhood increases future risk of adult hypertension and subsequent cardiovascular disease (CVD). Increased CVD risk is also observed with low SES, [9, 10] potentially due in part to differences in dietary intakes. Furthermore, prolonged inequalities of SES across the life course are likely to accumulate to overall greater CVD risk, [11, 12] A number of studies in adults[13-15] and in children and adolescents[16-20] have identified SES as a determinant of diet quality. For instance, evidence from cross-sectional studies in children and adolescents have reported a positive association between SES and fruit and vegetable intake[17, 18, 21] and conversely, lower levels of SES have been associated with poor dietary outcomes, including greater intake of high fat foods,[20] fast foods and soft drinks.[19] Studies examining the association between SES and sodium intake are scarce and inconsistent, one study in British adults found low SES was associated with higher intakes of sodium, [22] whereas in US adults there was no association between SES and sodium intake. [23] The aim of this study was to examine the association between SES and dietary sodium intake and the food sources of sodium in a nationally representative sample of Australian children aged 2-16 years.

METHODS

Study design

The 2007 Australian Children's Nutrition and Physical Activity Survey (CNPAS) was a cross-sectional survey designed to collect demographic, dietary, anthropometric and physical activity data from a nationally representative sample of children aged 2-16 years. The full details of the sampling methodology can be found elsewhere.(24) Briefly, participants were recruited using a multistage quota sampling framework. The initial target quota was 1000 participants for each of the following age groups; 2-3, 4-8, 9-13 and 14-16 years (50% boys and 50% girls), to which a 400 booster sample was later provided by the state of South Australia. The primary sampling unit was postcode and clusters of postcodes were randomly selected as stratified by state/territory and by capital city statistical division or rest of state/territory. Randomly selected clusters of postcodes ensured an equal number of participants in each age group, from each of the metro and non-metro areas within each state. Within selected postcodes Random Digit Dialling (RDD) was used to invite eligible households, i.e. those with children aged 2-16 years, to participate in the study. Only one child from each household could participate in the study. The response rate of eligible children was 40%. Due to the non-proportionate nature of the sampling framework each participant was assigned a population weighting which weighted for age, gender and region. The study was approved by the National Health and Medical Research Council registered Ethics Committees of Commonwealth Scientific and Industrial Research Organisation and the University of South Australia. All participants, or where the child was aged <14 years the primary carer, provided written consent.(24)

Assessments

Demographic and food intake data was collected during a face to face computer assisted personal interview (CAPI) completed during February and August 2007. A three-pass 24 h

dietary recall was used to determine all food and beverages consumed from midnight to midnight on the day prior to the interview.[24] The three pass method includes the following stages i) provide a quick list of all foods and beverages ii) a series of probe questions relevant to each quick list item to gather more detailed information on time and place of consumption, any additions to the food item, portion size and brand name iii) finally, a recall review to validate information and make any necessary adjustments. Portion sizes were estimated using a validated food model booklet and standard household measures. To minimise error after data collection all interviews were reviewed by study dietitians to assess for unrealistic portion sizes, inadequate detail and typing errors. The primary carer of participants aged 9 years and under provided information on dietary intake.[24]

Sodium intake was calculated using the Australian nutrient composition database AUSNUT2007, specifically developed by the Food Standards Australia and New Zealand for the CNPAS.[25] A description of the food coding system using in this database has previously been described. [26] Daily sodium (mg) intake was converted to the salt equivalent (g) using the conversion 1 gram of sodium chloride (salt) = 390 mg sodium. Reported salt intake did not include salt added at the table or during cooking.

Indicator of socioeconomic status

Consistent with other dietary studies in children and adolescents we have used level of education attained by the primary carer and household income as markers of SES. [27, 28] The highest level of education attained by the primary carer was used to define SES. Based on this participants were grouped into one of three categories of SES; i) high: includes those

with a university/tertiary qualification ii) mid: includes those with an advanced diploma, diploma or certificate III/IV or trade certificate iii) low: includes those with some or no level of high school education. Parental income was used as a secondary indicator of SES. Reported parental income before tax was grouped into four categories i) AUD$ 0 to $31 999 ii) $31 200 to $51 999 iii) $52 000 to $103 999 iv) ≥ $104 000. Body weight and height were measured using standardised protocols.[29] BMI was calculated as body weight (kg) divided by the square of body height (m^2). Participants were grouped into weight categories (very underweight, underweight, healthy weight, overweight, obese) using the International Obesity Task Force BMI reference cut offs for children.[30, 31]

Statistical analysis

Statistical analyses were completed using STATA/SE 11 (StataCorp, College Station, Texas USA) and PASW Statistics 17.0 (PASW Inc, Chicago, IL, USA). A P value of <0.05 was considered significant. All analyses accounted for the complex survey design using the STATA svy command, specifying strata variable (region), cluster variable (post code) and population weighting (age, gender, region). Descriptive statistics are presented as mean (SD) or n (% weighted). Pearson correlation coefficient was used to assess the association between sodium intake, energy intake and BMI. To assess the association between SES, as defined by primary carer education level, and sodium intake, multiple regression analysis was used with adjustment for age, gender, energy intake and BMI. To further control for the effects of age, the analysis was repeated stratified by age group (i.e. 2-3; 4-8; 9-13; 14-16 years). These age categories are consistent with those used in Australian dietary guidelines [6]. As income level is sometimes used as a marker of SES [13] the association between parental income and sodium intake was also examined, with adjustment for age, gender, energy intake and BMI. The regression coefficient (β) with 95% CI, corresponding *P* values and the coefficient of determination (R^2) are presented. In a previous analysis[26] which included the same study population we used the population proportion formula[32] to calculate the contribution of sodium from sub-major food group categories, as defined in the CNPAS food group coding system.[24] The population proportion formula [32] is outlined below:

% of sodium from food group = [sum of sodium from food group (mg) / total sum of sodium from all foods (mg)] X 100

For the present study, we have utilised this list which identifies the main sources of dietary sodium, to determine if sodium intake from food group differs between low and high SES categories, based on primary carer education level. To do this, we calculated the mean sodium intake from each sub-major food group by SES category, and compared the mean sodium of low to high SES, using an independent T-test.

RESULTS

Basic characteristics of the 4 487 participants are listed in **Table 1**. As defined by parental education status, the proportion of children from low, mid and high SES background was relatively evenly distributed. Over two thirds of children fell within the two highest income bands. There was a significant positive correlation between sodium intake and energy intake (r = 0.69, P <0.001) and sodium intake and BMI (r = 0.22, P <0.001). Average daily sodium intake differed by SES (**Figure 1**, P <0.01). Regression analysis indicated that low SES was associated with a 195 mg/d (salt 0.5 g/d) greater intake of sodium. The association between

SES and sodium intake remained after adjustment for age, gender, energy intake and BMI (**Table 2**). When stratified by age group the association between sodium intake and SES remained significant between the ages of 4-13 years (**Table 2**), however there was no association between sodium intake and SES in 2-3 year olds or in 14-16 year olds (data not shown). There was no association between sodium intake and parental income (data not shown), however, only 28% of children fell within the two lowest income bands (**Table 1**)

Table 3 lists those sub-major food groups which contributed >1% to the groups' total daily sodium intake. Combined these 23 food groups accounted for 84.5% of total daily sodium intake. Regular breads and bread rolls contributed the most sodium. Moderate sources of sodium, contributing more than 4% of total sodium intake, included mixed dishes where cereal is the major ingredient (e.g. pizza, hamburger, sandwich, savoury rice and noodle based dishes), processed meat, gravies and savoury sauces, pastries, cheese, and breakfast cereals and bars. Compared to children of high SES, children of low SES had a significantly greater intake of sodium from processed meat, gravies and savoury sauce, pastries, breakfast cereals and bars, potatoes and potato snacks (e.g. potato crisps). The percentage difference in sodium intake in each of these categories was 46%, 31%, 24%, 16%, 39% and 46%, respectively **(Table 3).** Conversely, children of high SES background had a significantly greater intake of sodium from the food group containing cakes, buns, muffins, scones, cake-type desserts; and the food group described as batter-based products (e.g. pancakes, picklets). The percentage difference in sodium intake in each of these categories was 16% and 32%, respectively (**Table 3**).

DISCUSSION

In a nationally representative sample of Australian children aged 2-16 years, we found children of low SES background consumed 9% more dietary sodium, from food sources, than those of high SES background. The inverse association between sodium intake and SES was primarily driven by the association in children aged 4-13 years, particularly after adjustment for the important covariates age, gender, energy intake and BMI. In adult studies, low SES has been associated with more frequent consumption of high salt foods, such as soup, sauces, ready to eat meals, savoury seasonings, sausages and potato.[33, 34] Given parental control over children's food choices during these years, it is likely that SES disparities in adult food choices relating to high salt foods may filter down into children's eating practices. We found no association between SES and sodium intake in 2-3 and 14-16 year olds. Although some evidence indicates SES disparities in dietary patterns may be present during infancy,[35] it is possible such early differences are not seen in dietary patterns with the restricted range of food types. In the case of adolescents, as autonomy over food choices increases, other factors, such as peer-influence, taste and eating away from the home[36] may become more prominent determinants of dietary intake.

Using US National Health and Nutrition Examination Survey (NHANES) data, Mazur et al.[37] explored the association of SES, as indicated by head of household education status and household income, on sodium intake in Hispanic children aged 4-16 years. Interestingly, in this study lower levels of education were associated with lower sodium intake[37]. This is contrary to our own findings as well as past studies, which generally link lower SES to overall poorer dietary outcomes.[13] We found no association between sodium intake and level of income, however low income bands were underrepresented. This is in contrast to the findings in Hispanic children, where low household income was associated with a greater intake of dietary sodium.[37] In a New Zealand food survey, low cost 'home brand' labelled food products were found to contain greater quantities of sodium than the more expensive branded food products.[38] The impact of income on sodium intake in Australian children remains unclear and further research is required.

Previous studies in children have reported socioeconomic differences in the consumption of certain food groups.[39, 40] For example, in European children of low SES background, greater intake of starchy foods, meat products, savoury snacks such as hamburgers, sugar and confectionary, pizza, desserts and soft drinks have been reported.[39, 40] In the present study those food groups which were found to contribute more sodium to the diets of low SES children tended to include convenience style foods (i.e. pies/sausage rolls; savoury sauce and casserole base sauces; fried prepared potato; processed meat; potato snacks). Comparably, children of high SES background consumed greater amounts of sodium from cake and baked type products. However, a significant amount of sodium in baked products can be in sodium bicarbonate rather than in the form of sodium chloride. Sodium bicarbonate, unlike sodium chloride, has not been directly associated with adverse blood pressure outcomes.[41]

With reference to sodium intake data by age group[5] and comparison to the recommended daily Upper Limit of sodium[6] it is evident that Australian children of all ages across all SES backgrounds are consuming too much dietary sodium. However, for the first time our findings indicate that socioeconomic disparities exist in sodium intake in Australian children aged 9-13 years. To reduce sodium intake in children a comprehensive approach is required, firstly targeting food policy, to encourage product reformulation of lower sodium food products across all price ranges within the food supply. Secondly, consumer education and awareness campaigns, that encourage food choices which are based on fresh products with minimal processing; this may require strategies that equip parents with enhanced food preparation skills and knowledge of the 'hidden' salt added to many commonly eaten processed foods. Furthermore, it is apparent that these strategies need to reach lower SES groups.

The major strengths of this study include the use of a large nationally-representative sample of Australian children, with comprehensive and standardised collection of dietary intake. Limitations of the study include the use of a 24-hr dietary recall to assess sodium intake. Firstly, this method fails to capture the amount of salt coming from salt added at the table and during cooking and therefore is likely to underestimate the true value of salt intake.[42] The majority (77%) of dietary sodium consumed is from salt added to processed foods, whilst a smaller amount (11%) has been found to be derived from salt added at the table and during cooking.[43] In the present study, the higher intake of sodium reported in children from low SES background is attributable to differences in sodium intake from food sources only. In a previous analysis of these data, we found that children from low SES background (33%) were more likely to report adding salt at the table than children from high SES (25%).[26] Thus, it is likely that children of low SES background are consuming greater amounts of total daily sodium than reported in the present analysis. Secondly, assessment of sodium intake is limited by the quality of food composition databases, which may not capture the variation in sodium content of different brand products within each food group. [42, 44]

In summary, the findings of higher salt intakes from food sources in children of lower SES background, within in a nationally representative sample, provides focus for concern regarding salt related disease across the life course. This socioeconomic patterning of salt intake may in turn influence the SES disparity seen in hypertension and cardiovascular risk in adulthood. To reduce socioeconomic inequalities in health, interventions need to begin early in life and should include product reformulation of lower sodium food products across all price ranges, as well as consumer education and awareness campaigns which reach low SES groups.

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Table 1. Basic characteristics of Australian children and adolescents aged 2-16 years (n 4 487)

Characteristic	**n or mean**	**% or SD**
Male (n %)	2 249	51
Age (years) (mean SD)	9.1	4.3
Age group (n %)		
2-3 years	1071	12
4-8 years	1216	34
9-13 years	1110	33
14-16 years	1090	21
Socioeconomic status (n %)*		
Low SES	1414	30
Mid SES	1583	36
High SES	1490	34
Parental income (n %)†		
$0 to 31 999	500	11
$32 000 to 51 999	732	17
$52 000 to 103 999	1850	42
$≥104 000	1169	30
Weight status (n %)‡		
Underweight	212	5
Healthy weight	3267	72
Overweight	761	17
Obese	247	6
Energy (kJ/d) (mean SD)	8392	3156
Sodium (mg/d) (mean SD)	2473	1243
Salt equivalent (g/d) (mean SD)§	6.3	3.1

* SES as defined by the highest level of education attained by the primary carer

†Participants with missing information for parental income (n=236) excluded

‡Weight classification based on the International Obesity Task Force BMI reference cut offs (30, 31)

§Salt equivalents (i.e. sodium chloride: 1 g = 390 mg sodium)

Figure 1. Mean sodium intake (mg/d) by socioeconomic group (n = 4487)†

[JPEG IMAGE ATTACHED]

* Significantly different from high SES (*P* <0.001)

** Significantly different from high SES (*P* <0.05)

†SES as defined by the highest level of education attained by the primary carer

Table 2. Association between socioeconomic status (SES) and dietary sodium intake (390 mg/d) (1 g/d salt) in Australian children and adolescents aged 2-16 years (n 4 487) †

Variable	Total Sample (n=4 487)		Age group‡			
			4-8 years (n=1 216)		9-13 years (n=1 110)	
	β (95% CI)	P Value	β (95% CI)	P Value	β (95% CI)	P Value
Unadjusted						
High SES (reference)						
Mid SES	0.3 (0.03, 0.5)	0.03	0.2 (-0.1, 0.6)	0.17	0.2 (-0.2, 0.6)	0.319
Low SES	0.5 (0.3, 0.8)	<0.001	0.5 (0.1, 1.0)	0.02	0.5 (-0.02, 1.0)	0.06
	R^2=0.004	<0.01	R^2=0.008	0.05	R^2=0.004	0.16
Adjusted§						

High SES (reference)						
Mid SES	0.2 (0.01, 0.4)	0.04	0.2 (-0.1, 0.4)	0.13	0.2 (-0.2, 0.6)	0.23
Low SES	0.5 (0.2, 0.7)	<0.001	0.6 (0.2, 0.9)	0.001	0.6 (0.1, 1.0)	0.01
	R^2=0.49	<0.001	R^2=0.37	<0.001	R^2=0.36	<0.001

 Dependent variable is sodium intake in units of 390 mg/d (salt equivalent 1 g/d) and independent variable is SES entered as an indicator variable: high SES is the reference category

†SES as defined by the highest level of education attained by the primary carer

‡No association between salt intake and SES in age groups 2-3 years and 14-16 years (models not shown)

§Adjusted for gender, age, energy intake and BMI

Table 3. Dietary sources of sodium intake listed by their contribution to intake for the group and mean daily sodium intake by food group, by socioeconomic group‖

Food group	Total sample (n 4487)	SES Group†			
		Low (n 1414)	Mid (n 1583)	High (n 1490)	P value‡
	% contribution to total daily sodium intake	Mean sodium (SD) mg/d	Mean sodium (SD) mg/d	Mean sodium (SD) mg/d	
Regular breads and bread rolls	13.4	340 (315)	330 (300)	324 (317)	0.26
Mixed dishes where cereal is the major ingredient	8.7	214 (514)	256 (616)	172 (445)	0.07
Processed meat§	**7.6**	**216 (464)**	**180 (403)**	**168 (368)**	**0.02**
Gravies and savoury sauces‖	**6.5**	**182 (385)**	**166 (395)**	**139 (354)**	**0.01**
Pastries¶	**4.9**	**135 (400)**	**120 (352)**	**109 (345)**	**0.03**

Cheese	4.6	114 (209)	110 (190)	116 (186)	0.80
Breakfast cereals and bars	**4.2**	**113 (176)**	**101 (166)**	**97 (161)**	**0.03**
Dairy milk	3.9	95 (106)	94 (103)	100 (98)	0.25
Herbs, spices, seasonings and stock cubes	3.7	114 (482)	75 (246)	90 (301)	0.31
Sausages, frankfurts and saveloys	2.9	79 (259)	74 (136)	61 (201)	0.07
Mixed dishes where poultry/game is the major component	2.6	79 (268)	59 (194)	60 (238)	0.09
Soup (prepared, ready to eat)	2.6	51 (288)	74 (379)	65 (282)	0.25
English-style muffins, flat breads, and savoury sweet breads	2.4	55 (158)	58 (180)	67 (181)	0.17
Cakes, buns, muffins, scones,	**2.3**	**54 (153)**	**52 (144)**	**68 (176)**	**0.02**

cake-type desserts					
Savoury biscuits	2.2	49 (136)	57 (147)	57 (152)	0.34
Yeast, yeast, vegetable and meat extracts	2.0	47 (117)	55 (143)	45 (108)	0.70
Potatoes	**1.9**	**53 (128)**	**51 (127)**	**38 (106)**	**0.01**
Batter-based products††	**1.7**	**38 (161)**	**37 (150)**	**50 (180)**	**0.05**
Potato snacks	**1.7**	**51 (149)**	**40 (121)**	**35 (125)**	**0.03**
Pasta and pasta products	1.4	35 (142)	32 (130)	35 (138)	0.89
Sweet biscuits	1.2	29 (64)	33 (72)	27 (62)	0.61
Mixed dishes where beef, veal or lamb is the major component	1.1	32 (175)	21 (116)	28 (56)	0.53
Mature legumes and pulse	1.0	21 (149)	21 (137)	35 (258)	0.12

products and dishes

 Includes those sub-major food group categories that contribute >1.0% of sodium to daily intake ambiguous

†SES as defined by the highest level of education attained by the primary carer

‡Means are compared between low and high SES groups using independent T-test

§includes ham, bacon and processed delicatessen meat

includes pasta sauces and casserole bases

¶includes pies and sausage rolls

  includes potato gems and wedges

††includes pancakes and pikelets

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Is socioeconomic status associated with dietary sodium intake in Australian children? A cross-sectional study

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Dietary sodium intake and socioeconomic status in Australian children

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All authors have completed the Unified Competing Interest form atwww.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare: Carley Grimes had financial support in the form of a post graduate scholarship from the Heart Foundation, Australia for the submitted work; and had no financial relationships with any organisations that might have an interest in the submitted work in the previous three years, no other relationships or activities that could appear to have influenced the submitted work. Karen Campbell had no support from any organisation for the submitted work; no other relationships or activities that could appear to have influenced the submitted work. Caryl Nowson has received research funds from Meat & Livestock Australia; National Health and Medical Research Council, Wicking Foundation, National Heart Foundation, Australia, Helen MacPerhson Smith Trust and Red Cross Blood Bank. These payments are unrelated to the submitted work. Lynn Riddell has received research funds from Meat & Livestock Australia. These payments are unrelated to the submitted work.

Data sharing statement:

The authors declare that on request all data files are available for analysis from the corresponding author at carley.grimes@deakin.edu.au

ABSTRACT

Objective: To assess the association between socioeconomic status (SES) and dietary sodium intake, and identify if the major dietary sources of sodium differ by socioeconomic group in a nationally representative sample of Australian children.

Design: Cross-sectional survey.

Setting: 2007 Australian National Children's Nutrition and Physical Activity Survey.

Participants: A total of 4487 children aged 2-16 years completed all components of the survey.

Primary and secondary outcome measures: Sodium intake was determined via one 24-hr dietary recall. The population proportion formula was used to identify the major sources of dietary salt. SES was defined by the level of education attained by the primary carer. In addition parental income was used as a secondary indicator of SES.

Results: Dietary sodium intake of children of low SES background was 2576 (SEM 42) mg/d (salt equivalent 6.6 (0.1) g/d) which was greater than children of high SES background 2370 (35) mg/d (salt 6.1 (0.09) g/d) ($P<0.001$). After adjustment for age, gender, energy intake and body mass index, low SES children consumed 195 mg/d (salt 0.5 g/d) more sodium than high SES children ($P<0.001$). Low SES children had a greater intake of sodium from processed meat, gravies/sauces, pastries, breakfast cereals, potatoes and potato snacks (all $P<0.05$).

Conclusion: Australian children from a low SES background have on average a 9% greater intake of sodium from food sources compared to those from a high SES background.

22 Understanding the socioeconomic patterning of salt intake during childhood should be considered in interventions to reduce cardiovascular disease.

Article summary:

Article focus

- To assess the association between socioeconomic status (SES) and dietary sodium intake in Australian children and adolescents.
- To determine if the major dietary sources of sodium differ by socioeconomic group.

Key messages

- In Australian children socioeconomic status is inversely associated with dietary sodium intake.
- Children of low socioeconomic background consumed more sodium from convenience style foods including pies/sausage rolls; savoury sauces, fried prepared potato; processed meat and potato crisps.

Strengths and limitations of this study

- These results are based on a large nationally representative sample of Australian children and adolescents.
- Sodium intake was determined via a 24-hr dietary recall and therefore does not capture the amount of sodium derived from salt used at the table or during cooking.

The socioeconomic disparity of sodium intake reported in this study is attributable to differences in sodium intake from food sources only. Further research is required to understand how SES impacts on raising sodium intake.

INTRODUCTION

As in adults,[1] dietary sodium intake is positively associated with blood pressure in children.[2, 3] Comparable to other developed nations,[4] dietary sodium intake of Australian children is high and exceeds dietary recommendations.[5, 6] Given blood pressure follows a tracking pattern over the life course,[7, 8] it is likely that high sodium consumption during childhood increases future risk of adult hypertension and subsequent cardiovascular disease (CVD). Increased CVD risk is also observed with low SES, [9, 10] potentially due in part to differences in dietary intakes. Furthermore, prolonged inequalities of SES across the life course are likely to accumulate to overall greater CVD risk, [11, 12] A number of studies in adults[13-15] and in children and adolescents[16-20] have identified SES as a determinant of diet quality. For instance, evidence from cross-sectional studies in children and adolescents have reported a positive association between SES and fruit and vegetable intake[17, 18, 21] and conversely, lower levels of SES have been associated with poor dietary outcomes, including greater intake of high fat foods,[20] fast foods and soft drinks.[19] Studies examining the association between SES and sodium intake are scarce and inconsistent, one study in British adults found low SES was associated with higher intakes of sodium, [22] whereas in US adults there was no association between SES and sodium intake. [23] The aim of this study was to examine the association between SES and dietary sodium intake and the food sources of sodium in a nationally representative sample of Australian children aged 2-16 years.

METHODS

Study design

The 2007 Australian Children's Nutrition and Physical Activity Survey (CNPAS) was a cross-sectional survey designed to collect demographic, dietary, anthropometric and physical activity data from a nationally representative sample of children aged 2-16 years. The full details of the sampling methodology can be found elsewhere.[24] Briefly, participants were recruited using a multistage quota sampling framework. The initial target quota was 1000 participants for each of the following age groups; 2-3, 4-8, 9-13 and 14-16 years (50% boys and 50% girls), to which a 400 booster sample was later provided by the state of South Australia. The primary sampling unit was postcode and clusters of postcodes were randomly selected as stratified by state/territory and by capital city statistical division or rest of state/territory. Randomly selected clusters of postcodes ensured an equal number of participants in each age group, from each of the metro and non-metro areas within each state. Within selected postcodes Random Digit Dialling (RDD) was used to invite eligible households, i.e. those with children aged 2-16 years, to participate in the study. Only one child from each household could participate in the study. The response rate of eligible children was 40%. Due to the non-proportionate nature of the sampling framework each participant was assigned a population weighting which weighted for age, gender and region. The study was approved by the National Health and Medical Research Council registered Ethics Committees of Commonwealth Scientific and Industrial Research Organisation and the University of South Australia. All participants, or where the child was aged <14 years the primary carer, provided written consent.[24]

Assessments

Demographic and food intake data was collected during a face to face computer assisted personal interview (CAPI) completed during February and August 2007. A three-pass 24 h

dietary recall was used to determine all food and beverages consumed from midnight to midnight on the day prior to the interview.[24] The three pass method includes the following stages i) provide a quick list of all foods and beverages ii) a series of probe questions relevant to each quick list item to gather more detailed information on time and place of consumption, any additions to the food item, portion size and brand name iii) finally, a recall review to validate information and make any necessary adjustments. Portion sizes were estimated using a validated food model booklet and standard household measures. To minimise error after data collection all interviews were reviewed by study dietitians to assess for unrealistic portion sizes, inadequate detail and typing errors. The primary carer of participants aged 9 years and under provided information on dietary intake.[24]

Sodium intake was calculated using the Australian nutrient composition database AUSNUT2007, specifically developed by the Food Standards Australia and New Zealand for the CNPAS.[25] A description of the food coding system using in this database has previously been described. [26] Daily sodium (mg) intake was converted to the salt equivalent (g) using the conversion 1 gram of sodium chloride (salt) = 390 mg sodium. Reported salt intake did not include salt added at the table or during cooking.

Indicator of socioeconomic status

Consistent with other dietary studies in children and adolescents we have used level of education attained by the primary carer and household income as markers of SES. [27, 28] The highest level of education attained by the primary carer was used to define SES. Based on this participants were grouped into one of three categories of SES; i) high: includes those

with a university/tertiary qualification ii) mid: includes those with an advanced diploma, diploma or certificate III/IV or trade certificate iii) low: includes those with some or no level of high school education. Parental income was used as a secondary indicator of SES. Reported parental income before tax was grouped into four categories i) AUD$ 0 to $31 999 ii) $31 200 to $51 999 iii) $52 000 to $103 999 iv) ≥ $104 000. Body weight and height were measured using standardised protocols.[29] BMI was calculated as body weight (kg) divided by the square of body height (m^2). Participants were grouped into weight categories (very underweight, underweight, healthy weight, overweight, obese) using the International Obesity Task Force BMI reference cut offs for children.[30, 31]

Statistical analysis

Statistical analyses were completed using STATA/SE 11 (StataCorp, College Station, Texas USA) and PASW Statistics 17.0 (PASW Inc, Chicago, IL, USA). A P value of <0.05 was considered significant. All analyses accounted for the complex survey design using the STATA svy command, specifying strata variable (region), cluster variable (post code) and population weighting (age, gender, region). Descriptive statistics are presented as mean (SD) or n (% weighted). Pearson correlation coefficient was used to assess the association between sodium intake, energy intake and BMI. To assess the association between SES, as defined by primary carer education level, and sodium intake, multiple regression analysis was used with adjustment for age, gender, energy intake and BMI. To further control for the effects of age, the analysis was repeated stratified by age group (i.e. 2-3; 4-8; 9-13; 14-16 years). These age categories are consistent with those used in Australian dietary guidelines [6]. As income level is sometimes used as a marker of SES [13] the association between parental income and sodium intake was also examined, with adjustment for age, gender, energy intake and BMI. The regression coefficient (β) with 95% CI, corresponding *P* values and the coefficient of determination (R^2) are presented. In a previous analysis[26] which included the same study population we used the population proportion formula[32] to calculate the contribution of sodium from sub-major food group categories, as defined in the CNPAS food group coding system.[24] The population proportion formula [32] is outlined below:

% of sodium from food group = [sum of sodium from food group (mg) / total sum of sodium from all foods (mg)] X 100

For the present study, we have utilised this list which identifies the main sources of dietary sodium, to determine if sodium intake from food group differs between low and high SES categories, based on primary carer education level. To do this, we calculated the mean sodium intake from each sub-major food group by SES category, and compared the mean sodium of low to high SES, using an independent T-test.

RESULTS

Basic characteristics of the 4 487 participants are listed in **Table 1**. As defined by parental education status, the proportion of children from low, mid and high SES background was relatively evenly distributed. Over two thirds of children fell within the two highest income bands. There was a significant positive correlation between sodium intake and energy intake (r = 0.69, P <0.001) and sodium intake and BMI (r = 0.22, P <0.001). Average daily sodium intake differed by SES (**Figure 1**, P <0.01). Regression analysis indicated that low SES was associated with a 195 mg/d (salt 0.5 g/d) greater intake of sodium. The association between

SES and sodium intake remained after adjustment for age, gender, energy intake and BMI (**Table 2**). When stratified by age group the association between sodium intake and SES remained significant between the ages of 4-13 years (**Table 2**), however there was no association between sodium intake and SES in 2-3 year olds or in 14-16 year olds (data not shown). There was no association between sodium intake and parental income (data not shown), however, only 28% of children fell within the two lowest income bands (**Table 1**)

Table 3 lists those sub-major food groups which contributed >1% to the groups' total daily sodium intake. Combined these 23 food groups accounted for 84.5% of total daily sodium intake. Regular breads and bread rolls contributed the most sodium. Moderate sources of sodium, contributing more than 4% of total sodium intake, included mixed dishes where cereal is the major ingredient (e.g. pizza, hamburger, sandwich, savoury rice and noodle based dishes), processed meat, gravies and savoury sauces, pastries, cheese, and breakfast cereals and bars. Compared to children of high SES, children of low SES had a significantly greater intake of sodium from processed meat, gravies and savoury sauce, pastries, breakfast cereals and bars, potatoes and potato snacks (e.g. potato crisps). The percentage difference in sodium intake in each of these categories was 46%, 31%, 24%, 16%, 39% and 46%, respectively **(Table 3).** Conversely, children of high SES background had a significantly greater intake of sodium from the food group containing cakes, buns, muffins, scones, cake-type desserts; and the food group described as batter-based products (e.g. pancakes, picklets). The percentage difference in sodium intake in each of these categories was 16% and 32%, respectively (**Table 3**).

DISCUSSION

In a nationally representative sample of Australian children aged 2-16 years, we found children of low SES background consumed 9% more dietary sodium, from food sources, than those of high SES background. The inverse association between sodium intake and SES was primarily driven by the association in children aged 4-13 years, particularly after adjustment for the important covariates age, gender, energy intake and BMI. In adult studies, low SES has been associated with more frequent consumption of high salt foods, such as soup, sauces, ready to eat meals, savoury seasonings, sausages and potato.(33, 34) Given parental control over children's food choices during these years, it is likely that SES disparities in adult food choices relating to high salt foods may filter down into children's eating practices. We found no association between SES and sodium intake in 2-3 and 14-16 year olds. Although some evidence indicates SES disparities in dietary patterns may be present during infancy,(35) it is possible such early differences are not seen in dietary patterns with the restricted range of food types. In the case of adolescents, as autonomy over food choices increases, other factors, such as peer-influence, taste and eating away from the home(36) may become more prominent determinants of dietary intake.

Using US National Health and Nutrition Examination Survey (NHANES) data, Mazur et al.(37) explored the association of SES, as indicated by head of household education status and household income, on sodium intake in Hispanic children aged 4-16 years. Interestingly, in this study lower levels of education were associated with lower sodium intake(37). This is contrary to our own findings as well as past studies, which generally link lower SES to overall poorer dietary outcomes.(13) We found no association between sodium intake and level of income, however low income bands were underrepresented. This is in contrast to the findings in Hispanic children, where low household income was associated with a greater intake of dietary sodium.[37] In a New Zealand food survey, low cost 'home brand' labelled food products were found to contain greater quantities of sodium than the more expensive branded food products.[38] The impact of income on sodium intake in Australian children remains unclear and further research is required.

Previous studies in children have reported socioeconomic differences in the consumption of certain food groups.[39, 40] For example, in European children of low SES background, greater intake of starchy foods, meat products, savoury snacks such as hamburgers, sugar and confectionary, pizza, desserts and soft drinks have been reported.[39, 40] In the present study those food groups which were found to contribute more sodium to the diets of low SES children tended to include convenience style foods (i.e. pies/sausage rolls; savoury sauce and casserole base sauces; fried prepared potato; processed meat; potato snacks). Comparably, children of high SES background consumed greater amounts of sodium from cake and baked type products. However, a significant amount of sodium in baked products can be in sodium bicarbonate rather than in the form of sodium chloride. Sodium bicarbonate, unlike sodium chloride, has not been directly associated with adverse blood pressure outcomes.[41]

With reference to sodium intake data by age group[5] and comparison to the recommended daily Upper Limit of sodium[6] it is evident that Australian children of all ages across all SES backgrounds are consuming too much dietary sodium. However, for the first time our findings indicate that socioeconomic disparities exist in sodium intake in Australian children aged 9-13 years. To reduce sodium intake in children a comprehensive approach is required, firstly targeting food policy, to encourage product reformulation of lower sodium food products across all price ranges within the food supply. Secondly, consumer education and awareness campaigns, that encourage food choices which are based on fresh products with minimal processing; this may require strategies that equip parents with enhanced food preparation skills and knowledge of the 'hidden' salt added to many commonly eaten processed foods. Furthermore, it is apparent that these strategies need to reach lower SES groups.

The major strengths of this study include the use of a large nationally-representative sample of Australian children, with comprehensive and standardised collection of dietary intake. Limitations of the study include the use of a 24-hr dietary recall to assess sodium intake. Firstly, this method fails to capture the amount of salt coming from salt added at the table and during cooking and therefore is likely to underestimate the true value of salt intake.(42) The majority (77%) of dietary sodium consumed is from salt added to processed foods, whilst a smaller amount (11%) has been found to be derived from salt added at the table and during cooking.(43) In the present study, the higher intake of sodium reported in children from low SES background is attributable to differences in sodium intake from food sources only. In a previous analysis of these data, we found that children from low SES background (33%) were more likely to report adding salt at the table than children from high SES (25%).(26) Thus, it is likely that children of low SES background are consuming greater amounts of total daily sodium than reported in the present analysis. Secondly, assessment of sodium intake is limited by the quality of food composition databases, which may not capture the variation in sodium content of different brand products within each food group. (42, 44)

In summary, the findings of higher salt intakes from food sources in children of lower SES background, within in a nationally representative sample, provides focus for concern regarding salt related disease across the life course. This socioeconomic patterning of salt intake may in turn influence the SES disparity seen in hypertension and cardiovascular risk in adulthood. To reduce socioeconomic inequalities in health, interventions need to begin early in life and should include product reformulation of lower sodium food products across all price ranges, as well as consumer education and awareness campaigns which reach low SES groups.

Contributorship statement: The author's responsibilities were as follows – CAG, KJC, LJR and CAN designed research; CAG performed statistical analysis and wrote the manuscript and is guarantor of the paper; LJR, KJC and CAN helped with data interpretation, revision of manuscript and provided significant consultation. All authors have read and approved the final manuscript.

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Table 1. Basic characteristics of Australian children and adolescents aged 2-16 years (n 4 487)

Characteristic	**n or mean**	**% or SD**
Male (n %)	2 249	51
Age (years) (mean SD)	9.1	4.3
Age group (n %)		
2-3 years	1071	12
4-8 years	1216	34
9-13 years	1110	33
14-16 years	1090	21
Socioeconomic status (n %)*		
Low SES	1414	30
Mid SES	1583	36
High SES	1490	34
Parental income (n %)†		
$0 to 31 999	500	11
$32 000 to 51 999	732	17
$52 000 to 103 999	1850	42
$≥104 000	1169	30
Weight status (n %)‡		
Underweight	212	5
Healthy weight	3267	72
Overweight	761	17
Obese	247	6
Energy (kJ/d) (mean SD)	8392	3156
Sodium (mg/d) (mean SD)	2473	1243
Salt equivalent (g/d) (mean SD)§	6.3	3.1

* SES as defined by the highest level of education attained by the primary carer

†Participants with missing information for parental income (n=236) excluded

‡Weight classification based on the International Obesity Task Force BMI reference cut offs (30, 31)

§Salt equivalents (i.e. sodium chloride: 1 g = 390 mg sodium)

Figure 1. Mean sodium intake (mg/d) by socioeconomic group (n = 4487)†

[JPEG IMAGE ATTACHED]

* Significantly different from high SES (*P* <0.001)

** Significantly different from high SES (*P* <0.05)

†SES as defined by the highest level of education attained by the primary carer

Table 2. Association between socioeconomic status (SES) and dietary sodium intake (390 mg/d) (1 g/d salt) in Australian children and adolescents aged 2-16 years (n 4 487) †

Variable	**Total Sample (n=4 487)**		**Age group‡**			
			4-8 years (n=1 216)		**9-13 years (n=1 110)**	
	β (95% CI)	**P Value**	**β (95% CI)**	**P Value**	**β (95% CI)**	**P Value**
Unadjusted						
High SES (reference)						
Mid SES	0.3 (0.03, 0.5)	0.03	0.2 (-0.1, 0.6)	0.17	0.2 (-0.2, 0.6)	0.319
Low SES	0.5 (0.3, 0.8)	<0.001	0.5 (0.1, 1.0)	0.02	0.5 (-0.02, 1.0)	0.06
	R^2=0.004	<0.01	R^2=0.008	0.05	R^2=0.004	0.16
Adjusted§						

High SES (reference)						
Mid SES	0.2 (0.01, 0.4)	0.04	0.2 (-0.1, 0.4)	0.13	0.2 (-0.2, 0.6)	0.23
Low SES	0.5 (0.2, 0.7)	<0.001	0.6 (0.2, 0.9)	0.001	0.6 (0.1, 1.0)	0.01
	R^2=0.49	<0.001	R^2=0.37	<0.001	R^2=0.36	<0.001

▯ Dependent variable is sodium intake in units of 390 mg/d (salt equivalent 1 g/d) and independent variable is SES entered as an indicator variable: high SES is the reference category

†SES as defined by the highest level of education attained by the primary carer

‡No association between salt intake and SES in age groups 2-3 years and 14-16 years (models not shown)

§Adjusted for gender, age, energy intake and BMI

Table 3. Dietary sources of sodium intake listed by their contribution to intake for the group and mean daily sodium intake by food group, by socioeconomic group

Food group	Total sample	SES Group†			
	(n 4487)	Low (n 1414)	Mid (n 1583)	High (n 1490)	P value‡
	% contribution to total daily sodium intake	Mean sodium (SD) mg/d	Mean sodium (SD) mg/d	Mean sodium (SD) mg/d	
Regular breads and bread rolls	13.4	340 (315)	330 (300)	324 (317)	0.26
Mixed dishes where cereal is the major ingredient	8.7	214 (514)	256 (616)	172 (445)	0.07
Processed meat§	**7.6**	**216 (464)**	**180 (403)**	**168 (368)**	**0.02**
Gravies and savoury sauces	**6.5**	**182 (385)**	**166 (395)**	**139 (354)**	**0.01**
Pastries¶	**4.9**	**135 (400)**	**120 (352)**	**109 (345)**	**0.03**

Cheese	4.6	114 (209)	110 (190)	116 (186)	0.80
Breakfast cereals and bars	**4.2**	**113 (176)**	**101 (166)**	**97 (161)**	**0.03**
Dairy milk	3.9	95 (106)	94 (103)	100 (98)	0.25
Herbs, spices, seasonings and stock cubes	3.7	114 (482)	75 (246)	90 (301)	0.31
Sausages, frankfurts and saveloys	2.9	79 (259)	74 (136)	61 (201)	0.07
Mixed dishes where poultry/game is the major component	2.6	79 (268)	59 (194)	60 (238)	0.09
Soup (prepared, ready to eat)	2.6	51 (288)	74 (379)	65 (282)	0.25
English-style muffins, flat breads, and savoury sweet breads	2.4	55 (158)	58 (180)	67 (181)	0.17
Cakes, buns, muffins, scones,	**2.3**	**54 (153)**	**52 (144)**	**68 (176)**	**0.02**

cake-type desserts					
Savoury biscuits	2.2	49 (136)	57 (147)	57 (152)	0.34
Yeast, yeast, vegetable and meat extracts	2.0	47 (117)	55 (143)	45 (108)	0.70
Potatoes	**1.9**	**53 (128)**	**51 (127)**	**38 (106)**	**0.01**
Batter-based products††	**1.7**	**38 (161)**	**37 (150)**	**50 (180)**	**0.05**
Potato snacks	**1.7**	**51 (149)**	**40 (121)**	**35 (125)**	**0.03**
Pasta and pasta products	1.4	35 (142)	32 (130)	35 (138)	0.89
Sweet biscuits	1.2	29 (64)	33 (72)	27 (62)	0.61
Mixed dishes where beef, veal or lamb is the major component	1.1	32 (175)	21 (116)	28 (56)	0.53
Mature legumes and pulse	1.0	21 (149)	21 (137)	35 (258)	0.12

products and dishes

 Includes those sub-major food group categories that contribute >1.0% of sodium to daily intake ambiguous

†SES as defined by the highest level of education attained by the primary carer

‡Means are compared between low and high SES groups using independent T-test

§includes ham, bacon and processed delicatessen meat

includes pasta sauces and casserole bases

¶includes pies and sausage rolls

  includes potato gems and wedges

††includes pancakes and pikelets

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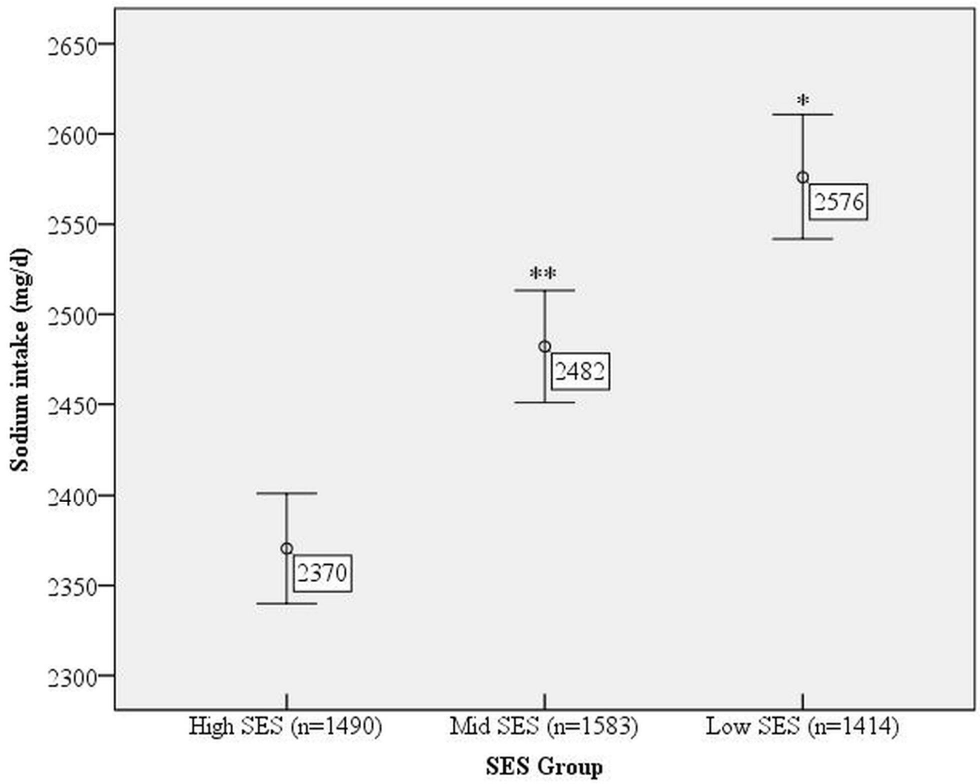

* Significantly different from high SES (P <0.001)
** Significantly different from high SES (P <0.05)
†SES as defined by the highest level of education attained by the primary carer
112x90mm (300 x 300 DPI)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.