



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

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Manuscripts

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3 **Dietary sodium intake is associated with socioeconomic status in Australian children: a**
4 **cross-sectional study**
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Data sharing statement:

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

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3 1 **ABSTRACT**
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6 2 **Objective:** To assess the association between socioeconomic status (SES) and dietary sodium
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8 3 intake, and identify if the major dietary sources of sodium differ by socioeconomic group in a
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10 4 nationally representative sample of Australian children.
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12
13 5 **Design:** Cross-sectional survey.
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16 6 **Setting:** 2007 Australian National Children's Nutrition and Physical Activity Survey.
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19 7 **Participants:** A total of 4487 children aged 2-16 years completed all components of the
20
21 8 survey.
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24 9 **Primary and secondary outcome measures:** Sodium intake was determined via one 24-hr
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26 10 dietary recall. The population proportion formula was used to identify the major sources of
27
28 11 dietary salt. SES was defined by the level of education attained by the primary carer. In
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30 12 addition parental income was used as a secondary indicator of SES.
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34 13 **Results:** Dietary sodium intake of children of low SES background was 2576 (SEM 42) mg/d
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36 14 (salt equivalent 6.6 (0.1) g/d) which was greater than children of high SES background 2370
37
38 15 (35) mg/d (salt 6.1 (0.09) g/d) ($P<0.001$). After adjustment for age, gender, energy intake
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40 16 and body mass index, low SES children consumed 195 mg/d (salt 0.5 g/d) more sodium than
41
42 17 high SES children ($P<0.001$). Low SES children had a greater intake of sodium from
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44 18 processed meat, gravies/sauces, pastries, breakfast cereals, potatoes and potato snacks (all
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46 19 $P<0.05$).
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50 20 **Conclusion:** Australian children from a low SES background have on average a 9% greater
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52 21 intake of sodium from food sources compared to those from a high SES background. This
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54 22 socioeconomic patterning of salt intake may in turn influence the SES disparity seen in
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23 hypertension and cardiovascular risk in adulthood. Understanding these differences in
24 childhood risk provide important focus for intervention.

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3 25 **Article summary:**
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6 26 **Article focus**
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- 8
9 27 • To assess the association between socioeconomic status (SES) and dietary sodium intake
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11 28 in Australian children and adolescents.
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14 29 • To determine if the major dietary sources of sodium differ by socioeconomic group.
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17 30 **Key messages**
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- 19
20 31 • In Australian children socioeconomic status is inversely associated with dietary sodium
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22 32 intake.
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26 33 • Children of low socioeconomic background consumed more sodium from convenience
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28 34 style foods including pies/sausage rolls; savoury sauces, fried prepared potato; processed
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30 35 meat and potato crisps.
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33 36 **Strengths and limitations of this study**
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36 37 • These results are based on a large nationally representative sample of Australian children
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38 38 and adolescents.
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41 39 • Sodium intake was determined via a 24-hr dietary recall and therefore does not capture the
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43 40 amount of sodium derived from salt used at the table or during cooking.
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46 47 • The socioeconomic disparity of sodium intake reported in this study is attributable to
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48 42 differences in sodium intake from food sources only. Further research is required to
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50 43 understand the influence of SES on total daily sodium intake.
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45 INTRODUCTION

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

65 METHODS

66 Study design

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3 67 The 2007 Australian Children's Nutrition and Physical Activity Survey (CNPAS) was a
4
5 68 cross-sectional survey designed to collect demographic, dietary, anthropometric and physical
6
7 69 activity data from a nationally representative sample of children aged 2-16 years. The full
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9 70 details of the sampling methodology can be found elsewhere.⁽²⁴⁾ Briefly, participants were
10
11 71 recruited using a multistage quota sampling framework. The initial target quota was 1000
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13 72 participants for each of the following age groups; 2-3, 4-8, 9-13 and 14-16 years (50% boys
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15 73 and 50% girls), to which a 400 booster sample was later provided by the state of South
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17 74 Australia. The primary sampling unit was postcode and clusters of postcodes were randomly
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19 75 selected as stratified by state/territory and by capital city statistical division or rest of
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21 76 state/territory. Randomly selected clusters of postcodes ensured an equal number of
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23 77 participants in each age group, from each of the metro and non-metro areas within each state.
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25 78 Within selected postcodes Random Digit Dialling (RDD) was used to invite eligible
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27 79 households, i.e. those with children aged 2-16 years, to participate in the study. Only one
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29 80 child from each household could participate in the study. The response rate of eligible
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31 81 children was 40%. Due to the non-proportionate nature of the sampling framework each
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33 82 participant was assigned a population weighting which weighted for age, gender and region.
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35 83 The study was approved by the National Health and Medical Research Council registered
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37 84 Ethics Committees of Commonwealth Scientific and Industrial Research Organisation and
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39 85 the University of South Australia. All participants, or where the child was aged <14 years the
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41 86 primary carer, provided written consent.⁽²⁴⁾
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51 **Assessments**

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54 89 Demographic and food intake data was collected during a face to face computer assisted
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56 90 personal interview (CAPI) completed during February and August 2007. A three-pass 24 h
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3 91 dietary recall was used to determine all food and beverages consumed from midnight to
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5 92 midnight on the day prior to the interview.⁽²⁴⁾ The primary carer of participants aged 9 years
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7 93 and under provided information on dietary intake.⁽²⁴⁾ Sodium intake was calculated using the
8
9 94 Australian nutrient composition database AUSNUT2007, specifically developed by the Food
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11 95 Standards Australia and New Zealand for the CNPAS.⁽²⁵⁾ Daily sodium (mg) intake was
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13 96 converted to the salt equivalent (g) using the conversion 1 gram of sodium chloride (salt) =
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15 97 390 mg sodium. Reported salt intake did not include salt added at the table or during
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17 98 cooking.
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24 100 The highest level of education attained by the primary carer was used to define SES. Based
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26 101 on this participants were grouped into one of three categories of SES; i) high: includes those
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28 102 with a university/tertiary qualification ii) mid: includes those with an advanced diploma,
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30 103 diploma or certificate III/IV or trade certificate iii) low: includes those with some or no level
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32 104 of high school education. Parental income was used as a secondary indicator of SES.
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34 105 Reported parental income before tax was grouped into four categories i) AUD\$ 0 to \$31 999
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36 106 ii) \$31 200 to \$51 999 iii) \$52 000 to \$103 999 iv) \geq \$104 000. Body weight and height were
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38 107 measured using standardised protocols.⁽²⁶⁾ BMI was calculated as body weight (kg) divided
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40 108 by the square of body height (m²). Participants were grouped into weight categories (very
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42 109 underweight, underweight, healthy weight, overweight, obese) using the International
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44 110 Obesity Task Force BMI reference cut offs for children.^(27, 28)
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53 112 **Statistical analysis**
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3 113 Statistical analyses were completed using STATA/SE 11 (StataCorp, College Station, Texas
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5 114 USA) and PASW Statistics 17.0 (PASW Inc, Chicago, IL, USA). A *P* value of <0.05 was
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7 115 considered significant. All analyses accounted for the complex survey design using the
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10 116 STATA svy command, specifying strata variable (region), cluster variable (post code) and
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12 117 population weighting (age, gender, region). Descriptive statistics are presented as mean (SD)
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14 118 or n (% weighted). To assess the association between SES, as defined by primary carer
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16 119 education level, and sodium intake, multiple regression analysis was used with adjustment for
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18 120 age, gender, energy intake and BMI. To further control for the effects of age, the analysis
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21 121 was repeated stratified by age group (i.e. 2-3; 4-8; 9-13; 14-16 years). These age categories
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23 122 are consistent with those used in Australian dietary guidelines⁽⁶⁾. As income level is
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25 123 sometimes used as a marker of SES⁽¹³⁾ the association between parental income and sodium
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27 124 intake was also examined, with adjustment for age, gender, energy intake and BMI. The
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29 125 regression coefficient (β) with 95% CI, corresponding *P* values and the coefficient of
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31 126 determination (R^2) are presented. In a previous analysis⁽²⁹⁾ which included the same study
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33 127 population we used the population proportion formula⁽³⁰⁾ to calculate the contribution of
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35 128 sodium from sub-major food group categories, as defined in the CNPAS food group coding
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37 129 system.⁽²⁴⁾ For the present study, we have utilised this list which identifies the main sources
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39 130 of dietary sodium, to determine if sodium intake from food group differs between low and
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41 131 high SES categories, based on primary carer education level. To do this, we calculated the
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43 132 mean sodium intake from each sub-major food group by SES category, and compared the
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45 133 mean sodium of low to high SES, using an independent T-test.
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54 135 RESULTS

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3 136 Basic characteristics of the 4 487 participants are listed in **Table 1**. As defined by parental
4
5 137 education status, the proportion of children from low, mid and high SES background was
6
7 138 relatively evenly distributed. Over two thirds of children fell within the two highest income
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9 139 bands. Average daily sodium intake differed by SES (**Figure 1**, $P < 0.01$). Regression
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11 140 analysis indicated that low SES was associated with a 195 mg/d (salt 0.5 g/d) greater intake
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13 141 of sodium. The association between SES and sodium intake remained after adjustment for
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15 142 age, gender, energy intake and BMI (**Table 2**). When stratified by age group the association
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17 143 between sodium intake and SES remained significant between the ages of 4-13 years (**Table**
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19 144 **2**), however there was no association between sodium intake and SES in 2-3 year olds or in
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21 145 14-16 year olds (data not shown). There was no association between sodium intake and
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23 146 parental income (data not shown), however, only 28% of children fell within the two lowest
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25 147 income bands (**Table 1**)
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33 149 **Table 3** lists those sub-major food groups which contributed $>1\%$ to the groups' total daily
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35 150 sodium intake. Combined these 23 food groups accounted for 84.5% of total daily sodium
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37 151 intake. Regular breads and bread rolls contributed the most sodium. Moderate sources of
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39 152 sodium, contributing more than 4% of total sodium intake, included mixed dishes where
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41 153 cereal is the major ingredient (e.g. pizza, hamburger, sandwich, savoury rice and noodle
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43 154 based dishes), processed meat, gravies and savoury sauces, pastries, cheese, and breakfast
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45 155 cereals and bars. Compared to children of high SES, children of low SES had a significantly
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47 156 greater intake of sodium from processed meat, gravies and savoury sauce, pastries, breakfast
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49 157 cereals and bars, potatoes and potato snacks (e.g. potato crisps). The percentage difference in
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51 158 sodium intake in each of these categories was 46%, 31%, 24%, 16%, 39% and 46%,
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53 159 respectively (**Table 3**). Conversely, children of high SES background had a significantly
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3 160 greater intake of sodium from the food group containing cakes, buns, muffins, scones, cake-
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5 161 type desserts; and the food group described as batter-based products (e.g. pancakes, picklets).
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7 162 The percentage difference in sodium intake in each of these categories was 16% and 32%,
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9 163 respectively (**Table 3**).
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165 **DISCUSSION**

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

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3 182 Using US National Health and Nutrition Examination Survey (NHANES) data, Mazur et
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5 183 al.⁽³⁵⁾ explored the association of SES, as indicated by head of household education status and
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7 184 household income, on sodium intake in Hispanic children aged 4-16 years. Interestingly, in
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9 185 this study lower levels of education were associated with lower sodium intake⁽³⁵⁾. This is
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11 186 contrary to our own findings as well as past studies, which generally link lower SES to
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13 187 overall poorer dietary outcomes.⁽¹³⁾ We found no association between sodium intake and
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15 188 level of income, however low income bands were underrepresented. This is in contrast to the
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17 189 findings in Hispanic children, where low household income was associated with a greater
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19 190 intake of dietary sodium.⁽³⁵⁾ In a New Zealand food survey, low cost 'home brand' labelled
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21 191 food products were found to contain greater quantities of sodium than the more expensive
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23 192 branded food products.⁽³⁶⁾ The impact of income on sodium intake in Australian children
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25 193 remains unclear and further research is required.
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33 195 Previous studies in children have reported socioeconomic differences in the consumption of
34
35 196 certain food groups.^(37, 38) For example, in European children of low SES background, greater
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37 197 intake of starchy foods, meat products, savoury snacks such as hamburgers, sugar and
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39 198 confectionary, pizza, desserts and soft drinks have been reported.^(37, 38) In the present study
40
41 199 those food groups which were found to contribute more sodium to the diets of low SES
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43 200 children tended to include convenience style foods (i.e. pies/sausage rolls; savoury sauce and
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45 201 casserole base sauces; fried prepared potato; processed meat; potato snacks). Comparably,
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47 202 children of high SES background consumed greater amounts of sodium from cake and baked
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49 203 type products. However, a significant amount of sodium in baked products can be in sodium
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51 204 bicarbonate rather than in the form of sodium chloride. Sodium bicarbonate, unlike sodium
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53 205 chloride, has not been directly associated with adverse blood pressure outcomes.⁽³⁹⁾
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7 With reference to sodium intake data by age group⁽⁵⁾ and comparison to the recommended
8 daily Upper Limit of sodium⁽⁶⁾ it is evident that Australian children of all ages across all SES
9 backgrounds are consuming too much dietary sodium. However, for the first time our
10 findings indicate that socioeconomic disparities exist in sodium intake in Australian children
11 aged 9-13 years. To reduce sodium intake in children a comprehensive approach is required,
12 firstly targeting food policy, to encourage product reformulation of lower sodium food
13 products across all price ranges within the food supply. Secondly, consumer education and
14 awareness campaigns, that encourage food choices which are based on fresh products with
15 minimal processing; this may require strategies that equip parents with enhanced food
16 preparation skills and knowledge of the 'hidden' salt added to many commonly eaten
17 processed foods. Furthermore, it is apparent that these strategies need to reach lower SES
18 groups.

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

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3 230 the table than children from high SES (33%).⁽²⁹⁾ Thus, it is likely that children of low SES
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5 231 background are consuming greater amounts of total daily sodium than reported in the present
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7 232 analysis.
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13 234 In summary, the findings of higher salt intakes in children of lower SES background, within
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15 235 in a nationally representative sample, provides focus for concern regarding salt related
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17 236 disease across the life course. This socioeconomic patterning of salt intake may in turn
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20 237 influence the SES disparity seen in hypertension and cardiovascular risk in adulthood. To
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22 238 reduce socioeconomic inequalities in health, interventions need to begin early in life and
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24 239 should include product reformulation of lower sodium food products across all price ranges,
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26 240 as well as consumer education and awareness campaigns which reach low SES groups.
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33 242 **Contributorship statement:** The author's responsibilities were as follows – CAG, KJC, LJR
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35 243 and CAN designed research; CAG performed statistical analysis and wrote the manuscript
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37 244 and is guarantor of the paper; LJR, KJC and CAN helped with data interpretation, revision of
38
39 245 manuscript and provided significant consultation. All authors have read and approved the
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41 246 final manuscript.
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46 248 Foundation of Australia PP 08M 4074.
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Table 1. Basic characteristics of Australian children and adolescents aged 2-16 years (n 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

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‡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)

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3 **Figure 1.** Mean sodium intake (mg/d) by socioeconomic group (n = 4487)^{†‡}
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6 **[JPEG IMAGE ATTACHED]**
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18 * Significantly different from high SES ($P < 0.001$)
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21 ** Significantly different from high SES ($P < 0.05$)
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24 †SES as defined by the highest level of education attained by the primary carer
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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†			P value‡
		Low (n 1414)	Mid (n 1583)	High (n 1490)	
	% 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

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5 products and dishes
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8 ¶ Includes those sub-major food group categories that contribute >1.0% of sodium to daily intake ambiguous
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11 †SES as defined by the highest level of education attained by the primary carer
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14 ‡Means are compared between low and high SES groups using independent T-test
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17 §includes ham, bacon and processed delicatessen meat
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19
20 □includes pasta sauces and casserole bases
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22
23 ¶includes pies and sausage rolls
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26 ¶ ¶ includes potato gems and wedges
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29 ††includes pancakes and pikelets
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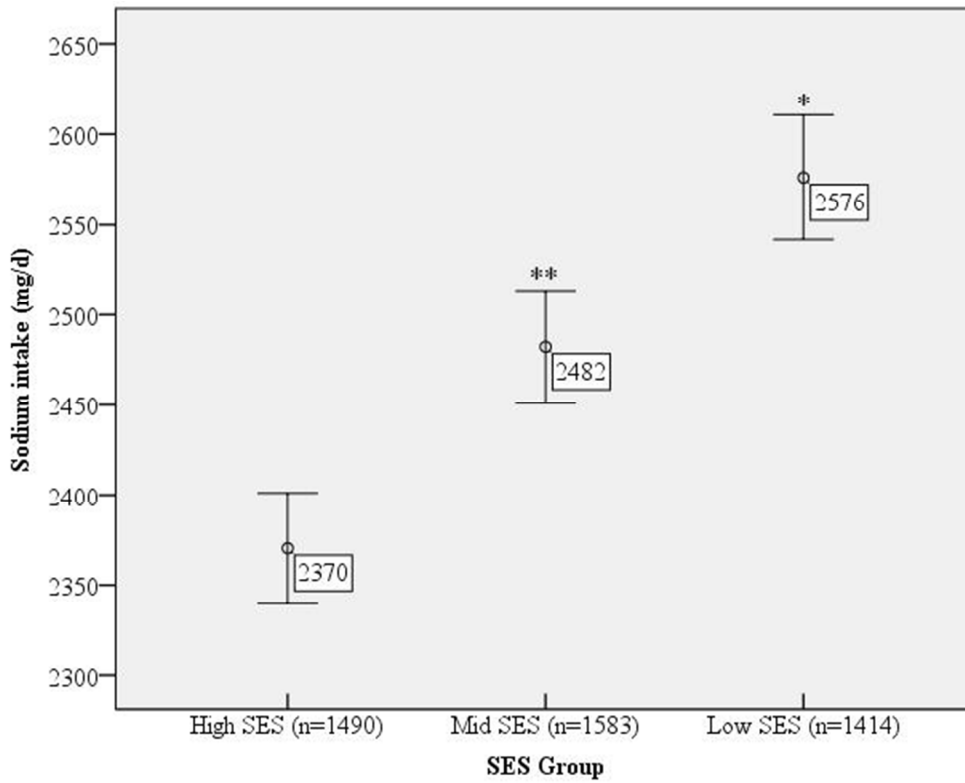
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* Significantly different from high SES (P <0.001)
** Significantly different from high SES (P <0.05)
†SES as defined by the highest level of education attained by the primary carer
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view only

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) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —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 <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants (b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —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) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy (e) Describe any sensitivity analyses

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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) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time <i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure <i>Cross-sectional study</i> —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
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*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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Primary Subject Heading:	Public health
Secondary Subject Heading:	Paediatrics, Cardiovascular medicine, Epidemiology
Keywords:	NUTRITION & DIETETICS, Community child health < PAEDIATRICS, EPIDEMIOLOGY

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Manuscripts

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6 **Is socioeconomic status associated with dietary sodium intake in Australian children? A**
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8 **cross-sectional study**
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Short title:

Dietary sodium intake and socioeconomic status in Australian children

Key words:

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

Word count: 2378

Declaration of competing interests:

All authors have completed the Unified Competing Interest form at www.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.

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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

For peer review only

1
2
3 **1 ABSTRACT**
4

5
6 **2 Objective:** To assess the association between socioeconomic status (SES) and dietary sodium
7
8 intake, and identify if the major dietary sources of sodium differ by socioeconomic group in a
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10 nationally representative sample of Australian children.
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13 **5 Design:** Cross-sectional survey.
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16 **6 Setting:** 2007 Australian National Children's Nutrition and Physical Activity Survey.
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20 **7 Participants:** A total of 4487 children aged 2-16 years completed all components of the
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22 survey.
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25 **9 Primary and secondary outcome measures:** Sodium intake was determined via one 24-hr
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27 dietary recall. The population proportion formula was used to identify the major sources of
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29 dietary salt. SES was defined by the level of education attained by the primary carer. In
30
31 addition parental income was used as a secondary indicator of SES.
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35 **13 Results:** Dietary sodium intake of children of low SES background was 2576 (SEM 42) mg/d
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37 (salt equivalent 6.6 (0.1) g/d) which was greater than children of high SES background 2370
38
39 (35) mg/d (salt 6.1 (0.09) g/d) ($P<0.001$). After adjustment for age, gender, energy intake
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41 and body mass index, low SES children consumed 195 mg/d (salt 0.5 g/d) more sodium than
42
43 high SES children ($P<0.001$). Low SES children had a greater intake of sodium from
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45 processed meat, gravies/sauces, pastries, breakfast cereals, potatoes and potato snacks (all
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47 $P<0.05$).
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51 **20 Conclusion:** Australian children from a low SES background have on average a 9% greater
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53 intake of sodium from food sources compared to those from a high SES background.
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22 Understanding the socioeconomic patterning of salt intake during childhood should be
23 considered in interventions to reduce cardiovascular disease.

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3 24 **Article summary:**
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6 25 **Article focus**
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- 8
9 26 • To assess the association between socioeconomic status (SES) and dietary sodium intake
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11 27 in Australian children and adolescents.
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14 28 • To determine if the major dietary sources of sodium differ by socioeconomic group.
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17 29 **Key messages**
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- 19
20 30 • In Australian children socioeconomic status is inversely associated with dietary sodium
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22 31 intake.
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25 32 • Children of low socioeconomic background consumed more sodium from convenience
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27 33 style foods including pies/sausage rolls; savoury sauces, fried prepared potato; processed
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29 34 meat and potato crisps.
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33 35 **Strengths and limitations of this study**
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36 36 • These results are based on a large nationally representative sample of Australian children
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38 37 and adolescents.
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41 38 • Sodium intake was determined via a 24-hr dietary recall and therefore does not capture the
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43 39 amount of sodium derived from salt used at the table or during cooking.
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47 40 The socioeconomic disparity of sodium intake reported in this study is attributable to
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49 41 differences in sodium intake from food sources only. Further research is required to
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51 42 understand how SES impacts on raising sodium intake.
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43 INTRODUCTION

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

63 METHODS

64 Study design

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3 65 The 2007 Australian Children's Nutrition and Physical Activity Survey (CNPAS) was a
4
5 66 cross-sectional survey designed to collect demographic, dietary, anthropometric and physical
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7 67 activity data from a nationally representative sample of children aged 2-16 years. The full
8
9 68 details of the sampling methodology can be found elsewhere.⁽²⁴⁾ Briefly, participants were
10
11 69 recruited using a multistage quota sampling framework. The initial target quota was 1000
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13 70 participants for each of the following age groups; 2-3, 4-8, 9-13 and 14-16 years (50% boys
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15 71 and 50% girls), to which a 400 booster sample was later provided by the state of South
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17 72 Australia. The primary sampling unit was postcode and clusters of postcodes were randomly
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19 73 selected as stratified by state/territory and by capital city statistical division or rest of
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21 74 state/territory. Randomly selected clusters of postcodes ensured an equal number of
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23 75 participants in each age group, from each of the metro and non-metro areas within each state.
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25 76 Within selected postcodes Random Digit Dialling (RDD) was used to invite eligible
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27 77 households, i.e. those with children aged 2-16 years, to participate in the study. Only one
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29 78 child from each household could participate in the study. The response rate of eligible
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31 79 children was 40%. Due to the non-proportionate nature of the sampling framework each
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33 80 participant was assigned a population weighting which weighted for age, gender and region.
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35 81 The study was approved by the National Health and Medical Research Council registered
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37 82 Ethics Committees of Commonwealth Scientific and Industrial Research Organisation and
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39 83 the University of South Australia. All participants, or where the child was aged <14 years the
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41 84 primary carer, provided written consent.⁽²⁴⁾
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51 **Assessments**

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54 87 Demographic and food intake data was collected during a face to face computer assisted
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56 88 personal interview (CAPI) completed during February and August 2007. A three-pass 24 h
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3 89 dietary recall was used to determine all food and beverages consumed from midnight to
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5 90 midnight on the day prior to the interview.⁽²⁴⁾ The three pass method includes the following
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7 91 stages i) provide a quick list of all foods and beverages ii) a series of probe questions relevant
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9 92 to each quick list item to gather more detailed information on time and place of consumption,
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11 93 any additions to the food item, portion size and brand name iii) finally, a recall review to
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13 94 validate information and make any necessary adjustments. Portion sizes were estimated
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15 95 using a validated food model booklet and standard household measures. To minimise error
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17 96 after data collection all interviews were reviewed by study dietitians to assess for unrealistic
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19 97 portion sizes, inadequate detail and typing errors. The primary carer of participants aged 9
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21 98 years and under provided information on dietary intake.⁽²⁴⁾
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29 100 Sodium intake was calculated using the Australian nutrient composition database
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31 101 AUSNUT2007, specifically developed by the Food Standards Australia and New Zealand for
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33 102 the CNPAS.⁽²⁵⁾ A description of the food coding system using in this database has previously
34
35 103 been described.⁽²⁶⁾ Daily sodium (mg) intake was converted to the salt equivalent (g) using
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37 104 the conversion 1 gram of sodium chloride (salt) = 390 mg sodium. Reported salt intake did
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39 105 not include salt added at the table or during cooking.
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46 107 *Indicator of socioeconomic status*

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49 108 Consistent with other dietary studies in children and adolescents we have used level of
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51 109 education attained by the primary carer and household income as markers of SES.^(27,28) The
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53 110 highest level of education attained by the primary carer was used to define SES. Based on
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55 111 this participants were grouped into one of three categories of SES; i) high: includes those
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3 112 with a university/tertiary qualification ii) mid: includes those with an advanced diploma,
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5 113 diploma or certificate III/IV or trade certificate iii) low: includes those with some or no level
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7 114 of high school education. Parental income was used as a secondary indicator of SES.
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9 115 Reported parental income before tax was grouped into four categories i) AUD\$ 0 to \$31 999
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11 116 ii) \$31 200 to \$51 999 iii) \$52 000 to \$103 999 iv) \geq \$104 000. Body weight and height were
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13 117 measured using standardised protocols.⁽²⁹⁾ BMI was calculated as body weight (kg) divided
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15 118 by the square of body height (m²). Participants were grouped into weight categories (very
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17 119 underweight, underweight, healthy weight, overweight, obese) using the International
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19 120 Obesity Task Force BMI reference cut offs for children.^(30,31)
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27 122 **Statistical analysis**

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30 123 Statistical analyses were completed using STATA/SE 11 (StataCorp, College Station, Texas
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32 124 USA) and PASW Statistics 17.0 (PASW Inc, Chicago, IL, USA). A *P* value of <0.05 was
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34 125 considered significant. All analyses accounted for the complex survey design using the
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36 126 STATA svy command, specifying strata variable (region), cluster variable (post code) and
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38 127 population weighting (age, gender, region). Descriptive statistics are presented as mean (SD)
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40 128 or n (% weighted). To assess the association between SES, as defined by primary carer
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42 129 education level, and sodium intake, multiple regression analysis was used with adjustment for
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44 130 age, gender, energy intake and BMI. To further control for the effects of age, the analysis
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46 131 was repeated stratified by age group (i.e. 2-3; 4-8; 9-13; 14-16 years). These age categories
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48 132 are consistent with those used in Australian dietary guidelines⁽⁶⁾. As income level is
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50 133 sometimes used as a marker of SES⁽¹³⁾ the association between parental income and sodium
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52 134 intake was also examined, with adjustment for age, gender, energy intake and BMI. The
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3 135 regression coefficient (β) with 95% CI, corresponding P values and the coefficient of
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5 136 determination (R^2) are presented. In a previous analysis⁽²⁶⁾ which included the same study
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7 137 population we used the population proportion formula⁽³²⁾ to calculate the contribution of
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10 138 sodium from sub-major food group categories, as defined in the CNPAS food group coding
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12 139 system.⁽²⁴⁾ The population proportion formula⁽³²⁾ is outlined below:

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15 140 **% of sodium from food group** = [sum of sodium from food group (mg) / total sum of
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18 141 sodium from all foods (mg)] X 100

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21 142 For the present study, we have utilised this list which identifies the main sources of dietary
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23 143 sodium, to determine if sodium intake from food group differs between low and high SES
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25 144 categories, based on primary carer education level. To do this, we calculated the mean
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27 145 sodium intake from each sub-major food group by SES category, and compared the mean
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29 146 sodium of low to high SES, using an independent T-test.
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36 148 **RESULTS**

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39 149 Basic characteristics of the 4 487 participants are listed in **Table 1**. As defined by parental
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41 150 education status, the proportion of children from low, mid and high SES background was
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43 151 relatively evenly distributed. Over two thirds of children fell within the two highest income
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45 152 bands. Average daily sodium intake differed by SES (**Figure 1**, $P < 0.01$). Regression
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47 153 analysis indicated that low SES was associated with a 195 mg/d (salt 0.5 g/d) greater intake
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49 154 of sodium. The association between SES and sodium intake remained after adjustment for
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51 155 age, gender, energy intake and BMI (**Table 2**). When stratified by age group the association
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53 156 between sodium intake and SES remained significant between the ages of 4-13 years (**Table**
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3 157 2), however there was no association between sodium intake and SES in 2-3 year olds or in
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5 158 14-16 year olds (data not shown). There was no association between sodium intake and
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7 159 parental income (data not shown), however, only 28% of children fell within the two lowest
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10 160 income bands (**Table 1**)

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16 162 **Table 3** lists those sub-major food groups which contributed >1% to the groups' total daily
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18 163 sodium intake. Combined these 23 food groups accounted for 84.5% of total daily sodium
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20 164 intake. Regular breads and bread rolls contributed the most sodium. Moderate sources of
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22 165 sodium, contributing more than 4% of total sodium intake, included mixed dishes where
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24 166 cereal is the major ingredient (e.g. pizza, hamburger, sandwich, savoury rice and noodle
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26 167 based dishes), processed meat, gravies and savoury sauces, pastries, cheese, and breakfast
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28 168 cereals and bars. Compared to children of high SES, children of low SES had a significantly
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30 169 greater intake of sodium from processed meat, gravies and savoury sauce, pastries, breakfast
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32 170 cereals and bars, potatoes and potato snacks (e.g. potato crisps). The percentage difference in
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34 171 sodium intake in each of these categories was 46%, 31%, 24%, 16%, 39% and 46%,
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36 172 respectively (**Table 3**). Conversely, children of high SES background had a significantly
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38 173 greater intake of sodium from the food group containing cakes, buns, muffins, scones, cake-
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40 174 type desserts; and the food group described as batter-based products (e.g. pancakes, picklets).
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42 175 The percentage difference in sodium intake in each of these categories was 16% and 32%,
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44 176 respectively (**Table 3**).

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53 178 **DISCUSSION**

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3 179 In a nationally representative sample of Australian children aged 2-16 years, we found
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5 180 children of low SES background consumed 9% more dietary sodium, from food sources, than
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7 181 those of high SES background. The inverse association between sodium intake and SES was
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9 182 primarily driven by the association in children aged 4-13 years, particularly after adjustment
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11 183 for the important covariates age, gender, energy intake and BMI. In adult studies, low SES
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13 184 has been associated with more frequent consumption of high salt foods, such as soup, sauces,
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15 185 ready to eat meals, savoury seasonings, sausages and potato.^(33, 34) Given parental control
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17 186 over children's food choices during these years, it is likely that SES disparities in adult food
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19 187 choices relating to high salt foods may filter down into children's eating practices. We found
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21 188 no association between SES and sodium intake in 2-3 and 14-16 year olds. Although some
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23 189 evidence indicates SES disparities in dietary patterns may be present during infancy,⁽³⁵⁾ it is
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25 190 possible such early differences are not seen in dietary patterns with the restricted range of
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27 191 food types. In the case of adolescents, as autonomy over food choices increases, other
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29 192 factors, such as peer-influence, taste and eating away from the home⁽³⁶⁾ may become more
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31 193 prominent determinants of dietary intake.
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40 195 Using US National Health and Nutrition Examination Survey (NHANES) data, Mazur et
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42 196 al.⁽³⁷⁾ explored the association of SES, as indicated by head of household education status and
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44 197 household income, on sodium intake in Hispanic children aged 4-16 years. Interestingly, in
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46 198 this study lower levels of education were associated with lower sodium intake⁽³⁷⁾. This is
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48 199 contrary to our own findings as well as past studies, which generally link lower SES to
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50 200 overall poorer dietary outcomes.⁽¹³⁾ We found no association between sodium intake and
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52 201 level of income, however low income bands were underrepresented. This is in contrast to the
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54 202 findings in Hispanic children, where low household income was associated with a greater
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3 203 intake of dietary sodium.⁽³⁷⁾ In a New Zealand food survey, low cost 'home brand' labelled
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5 204 food products were found to contain greater quantities of sodium than the more expensive
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7 205 branded food products.⁽³⁸⁾ The impact of income on sodium intake in Australian children
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10 206 remains unclear and further research is required.

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16 208 Previous studies in children have reported socioeconomic differences in the consumption of
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18 209 certain food groups.^(39, 40) For example, in European children of low SES background, greater
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20 210 intake of starchy foods, meat products, savoury snacks such as hamburgers, sugar and
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22 211 confectionary, pizza, desserts and soft drinks have been reported.^(39, 40) In the present study
23
24 212 those food groups which were found to contribute more sodium to the diets of low SES
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26 213 children tended to include convenience style foods (i.e. pies/sausage rolls; savoury sauce and
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28 214 casserole base sauces; fried prepared potato; processed meat; potato snacks). Comparably,
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30 215 children of high SES background consumed greater amounts of sodium from cake and baked
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32 216 type products. However, a significant amount of sodium in baked products can be in sodium
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34 217 bicarbonate rather than in the form of sodium chloride. Sodium bicarbonate, unlike sodium
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36 218 chloride, has not been directly associated with adverse blood pressure outcomes.⁽⁴¹⁾

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44 220 With reference to sodium intake data by age group⁽⁵⁾ and comparison to the recommended
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46 221 daily Upper Limit of sodium⁽⁶⁾ it is evident that Australian children of all ages across all SES
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48 222 backgrounds are consuming too much dietary sodium. However, for the first time our
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50 223 findings indicate that socioeconomic disparities exist in sodium intake in Australian children
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52 224 aged 9-13 years. To reduce sodium intake in children a comprehensive approach is required,
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54 225 firstly targeting food policy, to encourage product reformulation of lower sodium food
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3 226 products across all price ranges within the food supply. Secondly, consumer education and
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5 227 awareness campaigns, that encourage food choices which are based on fresh products with
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7 228 minimal processing; this may require strategies that equip parents with enhanced food
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10 229 preparation skills and knowledge of the 'hidden' salt added to many commonly eaten
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12 230 processed foods. Furthermore, it is apparent that these strategies need to reach lower SES
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14 231 groups.

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20 233 The major strengths of this study include the use of a large nationally-representative sample
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22 234 of Australian children, with comprehensive and standardised collection of dietary intake.
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24 235 Limitations of the study include the use of a 24-hr dietary recall to assess sodium intake.
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26 236 Firstly, this method fails to capture the amount of salt coming from salt added at the table and
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28 237 during cooking and therefore is likely to underestimate the true value of salt intake.⁽⁴²⁾ The
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30 238 majority (77%) of dietary sodium consumed is from salt added to processed foods, whilst a
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32 239 smaller amount (11%) has been found to be derived from salt added at the table and during
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34 240 cooking.⁽⁴³⁾ In the present study, the higher intake of sodium reported in children from low
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36 241 SES background is attributable to differences in sodium intake from food sources only. In a
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38 242 previous analysis of these data, we found that children from low SES background (33%) were
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40 243 more likely to report adding salt at the table than children from high SES (25%).⁽²⁶⁾ Thus, it
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42 244 is likely that children of low SES background are consuming greater amounts of total daily
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44 245 sodium than reported in the present analysis. Secondly, assessment of sodium intake is
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46 246 limited by the quality of food composition databases, which may not capture the variation in
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48 247 sodium content of different brand products within each food group.^(42, 44)

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3 249 In summary, the findings of higher salt intakes from food sources in children of lower SES
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5 250 background, within in a nationally representative sample, provides focus for concern
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7 251 regarding salt related disease across the life course. This socioeconomic patterning of salt
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9 252 intake may in turn influence the SES disparity seen in hypertension and cardiovascular risk in
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11 253 adulthood. To reduce socioeconomic inequalities in health, interventions need to begin early
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13 254 in life and should include product reformulation of lower sodium food products across all
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15 255 price ranges, as well as consumer education and awareness campaigns which reach low SES
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18 256 groups.
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25 258 **Contributorship statement:** The author's responsibilities were as follows – CAG, KJC, LJR
26
27 259 and CAN designed research; CAG performed statistical analysis and wrote the manuscript
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29 260 and is guarantor of the paper; LJR, KJC and CAN helped with data interpretation, revision of
30
31 261 manuscript and provided significant consultation. All authors have read and approved the
32
33 262 final manuscript.
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37
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Table 1. Basic characteristics of Australian children and adolescents aged 2-16 years (n 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)

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3 **Figure 1.** Mean sodium intake (mg/d) by socioeconomic group (n = 4487)^{†‡}
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6 **[JPEG IMAGE ATTACHED]**
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18 * Significantly different from high SES ($P < 0.001$)
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21 ** Significantly different from high SES ($P < 0.05$)
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24 †SES as defined by the highest level of education attained by the primary carer
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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[§]						

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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†			P value‡
		Low (n 1414)	Mid (n 1583)	High (n 1490)	
	% 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

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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

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5 products and dishes
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8 ¶ Includes those sub-major food group categories that contribute >1.0% of sodium to daily intake ambiguous
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11 †SES as defined by the highest level of education attained by the primary carer
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14 ‡Means are compared between low and high SES groups using independent T-test
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16
17 §includes ham, bacon and processed delicatessen meat
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19
20 □includes pasta sauces and casserole bases
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22
23 ¶includes pies and sausage rolls
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26 ¶ ¶ includes potato gems and wedges
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29 ††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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16 Dietary sodium intake and socioeconomic status in Australian children
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22 Sodium, Dietary; Sodium Chloride; Socioeconomic Status; Child; Australia
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39 relationships with any organisations that might have an interest in the submitted work in the
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41 previous three years, no other relationships or activities that could appear to have influenced
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43 the submitted work. Karen Campbell had no support from any organisation for the submitted
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45 work; no other relationships or activities that could appear to have influenced the submitted
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3 unrelated to the submitted work. Lynn Riddell has received research funds from Meat &
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5 Livestock Australia. These payments are unrelated to the submitted work.
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11 **Data sharing statement:**
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14 The authors declare that on request all data files are available for analysis from the
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16 corresponding author at carley.grimes@deakin.edu.au
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3 1 **ABSTRACT**
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6 2 **Objective:** To assess the association between socioeconomic status (SES) and dietary sodium
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8 3 intake, and identify if the major dietary sources of sodium differ by socioeconomic group in a
9
10 4 nationally representative sample of Australian children.
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13 5 **Design:** Cross-sectional survey.
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16 6 **Setting:** 2007 Australian National Children's Nutrition and Physical Activity Survey.
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19 7 **Participants:** A total of 4487 children aged 2-16 years completed all components of the
20
21 8 survey.
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24 9 **Primary and secondary outcome measures:** Sodium intake was determined via one 24-hr
25
26 10 dietary recall. The population proportion formula was used to identify the major sources of
27
28 11 dietary salt. SES was defined by the level of education attained by the primary carer. In
29
30 12 addition parental income was used as a secondary indicator of SES.
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34 13 **Results:** Dietary sodium intake of children of low SES background was 2576 (SEM 42) mg/d
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36 14 (salt equivalent 6.6 (0.1) g/d) which was greater than children of high SES background 2370
37
38 15 (35) mg/d (salt 6.1 (0.09) g/d) ($P<0.001$). After adjustment for age, gender, energy intake
39
40 16 and body mass index, low SES children consumed 195 mg/d (salt 0.5 g/d) more sodium than
41
42 17 high SES children ($P<0.001$). Low SES children had a greater intake of sodium from
43
44 18 processed meat, gravies/sauces, pastries, breakfast cereals, potatoes and potato snacks (all
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46 19 $P<0.05$).
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50 20 **Conclusion:** Australian children from a low SES background have on average a 9% greater
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52 21 intake of sodium from food sources compared to those from a high SES background. **This**
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54 22 ~~socioeconomic patterning of salt intake may in turn influence the SES disparity seen in~~
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3 23 | ~~hypertension and cardiovascular risk in adulthood.~~ Understanding these the differences in
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5 24 | socioeconomic patterning of salt intake during childhood ~~risk provides important focus for~~
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7 25 | intervention should be considered in interventions to reduce cardiovascular disease.
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3 26 **Article summary:**
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6 27 **Article focus**
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9 • To assess the association between socioeconomic status (SES) and dietary sodium intake
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11 in Australian children and adolescents.
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14 • To determine if the major dietary sources of sodium differ by socioeconomic group.
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17 31 **Key messages**
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20 • In Australian children socioeconomic status is inversely associated with dietary sodium
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22 intake.
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24 • Children of low socioeconomic background consumed more sodium from convenience
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26 style foods including pies/sausage rolls; savoury sauces, fried prepared potato; processed
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28 meat and potato crisps.
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33 37 **Strengths and limitations of this study**
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36 • These results are based on a large nationally representative sample of Australian children
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38 and adolescents.
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40 • Sodium intake was determined via a 24-hr dietary recall and therefore does not capture the
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42 amount of sodium derived from salt used at the table or during cooking.
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47 • The socioeconomic disparity of sodium intake reported in this study is attributable to
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49 differences in sodium intake from food sources only. Further research is required to
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51 understand [how SES impacts on raising sodium intake.](#) ~~on total daily sodium intake.~~
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46 INTRODUCTION

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

66 METHODS

67 Study design

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3 68 The 2007 Australian Children's Nutrition and Physical Activity Survey (CNPAS) was a
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5 69 cross-sectional survey designed to collect demographic, dietary, anthropometric and physical
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7 70 activity data from a nationally representative sample of children aged 2-16 years. The full
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9 71 details of the sampling methodology can be found elsewhere.⁽²⁴⁾ Briefly, participants were
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11 72 recruited using a multistage quota sampling framework. The initial target quota was 1000
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13 73 participants for each of the following age groups; 2-3, 4-8, 9-13 and 14-16 years (50% boys
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15 74 and 50% girls), to which a 400 booster sample was later provided by the state of South
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17 75 Australia. The primary sampling unit was postcode and clusters of postcodes were randomly
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19 76 selected as stratified by state/territory and by capital city statistical division or rest of
20
21 77 state/territory. Randomly selected clusters of postcodes ensured an equal number of
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23 78 participants in each age group, from each of the metro and non-metro areas within each state.
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25 79 Within selected postcodes Random Digit Dialling (RDD) was used to invite eligible
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27 80 households, i.e. those with children aged 2-16 years, to participate in the study. Only one
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29 81 child from each household could participate in the study. The response rate of eligible
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31 82 children was 40%. Due to the non-proportionate nature of the sampling framework each
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33 83 participant was assigned a population weighting which weighted for age, gender and region.
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35 84 The study was approved by the National Health and Medical Research Council registered
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37 85 Ethics Committees of Commonwealth Scientific and Industrial Research Organisation and
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39 86 the University of South Australia. All participants, or where the child was aged <14 years the
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41 87 primary carer, provided written consent.⁽²⁴⁾
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51 **Assessments**

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54 90 Demographic and food intake data was collected during a face to face computer assisted
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56 91 personal interview (CAPI) completed during February and August 2007. A three-pass 24 h
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3 92 dietary recall was used to determine all food and beverages consumed from midnight to
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5 93 midnight on the day prior to the interview.⁽²⁴⁾ The three pass method includes the following
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7 94 stages i) provide a quick list of all foods and beverages ii) a series of probe questions relevant
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9 95 to each quick list item to gather more detailed information on time and place of consumption,
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11 96 any additions to the food item, portion size and brand name iii) finally, a recall review to
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13 97 validate information and make any necessary adjustments. Portion sizes were estimated
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15 98 using a validated food model booklet and standard household measures. To minimise error
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17 99 after data collection all interviews were reviewed by study dietitians to assess for unrealistic
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19 100 portion sizes, inadequate detail and typing errors. The primary carer of participants aged 9
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21 101 years and under provided information on dietary intake.⁽²⁴⁾
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29 103 Sodium intake was calculated using the Australian nutrient composition database
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31 104 AUSNUT2007, specifically developed by the Food Standards Australia and New Zealand for
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33 105 the CNPAS.⁽²⁵⁾ A description of the food coding system using in this database has previously
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35 106 been described.⁽²⁶⁾ Daily sodium (mg) intake was converted to the salt equivalent (g) using
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37 107 the conversion 1 gram of sodium chloride (salt) = 390 mg sodium. Reported salt intake did
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39 108 not include salt added at the table or during cooking.
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46 110 *Indicator of socioeconomic status*

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49 111 Consistent with other dietary studies in children and adolescents we have used level of
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51 112 education attained by the primary carer and household income as markers of SES.^(27, 28) The
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53 113 highest level of education attained by the primary carer was used to define SES. Based on
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55 114 this participants were grouped into one of three categories of SES; i) high: includes those
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3 115 with a university/tertiary qualification ii) mid: includes those with an advanced diploma,
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5 116 diploma or certificate III/IV or trade certificate iii) low: includes those with some or no level
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7 117 of high school education. Parental income was used as a secondary indicator of SES.
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9 118 Reported parental income before tax was grouped into four categories i) AUD\$ 0 to \$31 999
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11 119 ii) \$31 200 to \$51 999 iii) \$52 000 to \$103 999 iv) \geq \$104 000. Body weight and height were
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13 120 measured using standardised protocols.⁽²⁹⁾ BMI was calculated as body weight (kg) divided
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15 121 by the square of body height (m²). Participants were grouped into weight categories (very
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17 122 underweight, underweight, healthy weight, overweight, obese) using the International
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19 123 Obesity Task Force BMI reference cut offs for children.^(30,31)
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27 125 **Statistical analysis**

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30 126 Statistical analyses were completed using STATA/SE 11 (StataCorp, College Station, Texas
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32 127 USA) and PASW Statistics 17.0 (PASW Inc, Chicago, IL, USA). A *P* value of <0.05 was
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34 128 considered significant. All analyses accounted for the complex survey design using the
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36 129 STATA svy command, specifying strata variable (region), cluster variable (post code) and
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38 130 population weighting (age, gender, region). Descriptive statistics are presented as mean (SD)
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40 131 or n (% weighted). To assess the association between SES, as defined by primary carer
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42 132 education level, and sodium intake, multiple regression analysis was used with adjustment for
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44 133 age, gender, energy intake and BMI. To further control for the effects of age, the analysis
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46 134 was repeated stratified by age group (i.e. 2-3; 4-8; 9-13; 14-16 years). These age categories
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48 135 are consistent with those used in Australian dietary guidelines⁽⁶⁾. As income level is
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50 136 sometimes used as a marker of SES⁽¹³⁾ the association between parental income and sodium
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52 137 intake was also examined, with adjustment for age, gender, energy intake and BMI. The
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3 138 regression coefficient (β) with 95% CI, corresponding P values and the coefficient of
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5 139 determination (R^2) are presented. In a previous analysis⁽²⁶⁾ which included the same study
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7 140 population we used the population proportion formula⁽³²⁾ to calculate the contribution of
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9 141 sodium from sub-major food group categories, as defined in the CNPAS food group coding
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11 142 system.⁽²⁴⁾ The population proportion formula⁽³²⁾ is outlined below:

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15 143 % of sodium from food group = [sum of sodium from food group (mg) / total sum of
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17 144 sodium from all foods (mg)] X 100

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21 145 For the present study, we have utilised this list which identifies the main sources of dietary
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23 146 sodium, to determine if sodium intake from food group differs between low and high SES
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25 147 categories, based on primary carer education level. To do this, we calculated the mean
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27 148 sodium intake from each sub-major food group by SES category, and compared the mean
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29 149 sodium of low to high SES, using an independent T-test.
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34 35 36 151 RESULTS

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39 152 Basic characteristics of the 4 487 participants are listed in **Table 1**. As defined by parental
40
41 153 education status, the proportion of children from low, mid and high SES background was
42
43 154 relatively evenly distributed. Over two thirds of children fell within the two highest income
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45 155 bands. Average daily sodium intake differed by SES (**Figure 1**, $P < 0.01$). Regression
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47 156 analysis indicated that low SES was associated with a 195 mg/d (salt 0.5 g/d) greater intake
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49 157 of sodium. The association between SES and sodium intake remained after adjustment for
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51 158 age, gender, energy intake and BMI (**Table 2**). When stratified by age group the association
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53 159 between sodium intake and SES remained significant between the ages of 4-13 years (**Table**
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3 160 2), however there was no association between sodium intake and SES in 2-3 year olds or in
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5 161 14-16 year olds (data not shown). There was no association between sodium intake and
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7 162 parental income (data not shown), however, only 28% of children fell within the two lowest
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9 163 income bands (**Table 1**)

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16 165 **Table 3** lists those sub-major food groups which contributed >1% to the groups' total daily
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18 166 sodium intake. Combined these 23 food groups accounted for 84.5% of total daily sodium
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20 167 intake. Regular breads and bread rolls contributed the most sodium. Moderate sources of
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22 168 sodium, contributing more than 4% of total sodium intake, included mixed dishes where
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24 169 cereal is the major ingredient (e.g. pizza, hamburger, sandwich, savoury rice and noodle
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26 170 based dishes), processed meat, gravies and savoury sauces, pastries, cheese, and breakfast
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28 171 cereals and bars. Compared to children of high SES, children of low SES had a significantly
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30 172 greater intake of sodium from processed meat, gravies and savoury sauce, pastries, breakfast
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32 173 cereals and bars, potatoes and potato snacks (e.g. potato crisps). The percentage difference in
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34 174 sodium intake in each of these categories was 46%, 31%, 24%, 16%, 39% and 46%,
35
36 175 respectively (**Table 3**). Conversely, children of high SES background had a significantly
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38 176 greater intake of sodium from the food group containing cakes, buns, muffins, scones, cake-
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40 177 type desserts; and the food group described as batter-based products (e.g. pancakes, picklets).
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42 178 The percentage difference in sodium intake in each of these categories was 16% and 32%,
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44 179 respectively (**Table 3**).
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53 181 **DISCUSSION**
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3 182 In a nationally representative sample of Australian children aged 2-16 years, we found
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5 183 children of low SES background consumed 9% more dietary sodium, from food sources, than
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7 184 those of high SES background. The inverse association between sodium intake and SES was
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10 185 primarily driven by the association in children aged 4-13 years, particularly after adjustment
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12 186 for the important covariates age, gender, energy intake and BMI. In adult studies, low SES
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14 187 has been associated with more frequent consumption of high salt foods, such as soup, sauces,
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16 188 ready to eat meals, savoury seasonings, sausages and potato.^(33, 34) Given parental control
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18 189 over children's food choices during these years, it is likely that SES disparities in adult food
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21 190 choices relating to high salt foods may filter down into children's eating practices. We found
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23 191 no association between SES and sodium intake in 2-3 and 14-16 year olds. Although some
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25 192 evidence indicates SES disparities in dietary patterns may be present during infancy,⁽³⁵⁾ it is
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27 193 possible such early differences are not seen in dietary patterns with the restricted range of
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29 194 food types. In the case of adolescents, as autonomy over food choices increases, other
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31 195 factors, such as peer-influence, taste and eating away from the home⁽³⁶⁾ may become more
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33 196 prominent determinants of dietary intake.
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40 198 Using US National Health and Nutrition Examination Survey (NHANES) data, Mazur et
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42 199 al.⁽³⁷⁾ explored the association of SES, as indicated by head of household education status and
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44 200 household income, on sodium intake in Hispanic children aged 4-16 years. Interestingly, in
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46 201 this study lower levels of education were associated with lower sodium intake⁽³⁷⁾. This is
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48 202 contrary to our own findings as well as past studies, which generally link lower SES to
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50 203 overall poorer dietary outcomes.⁽¹³⁾ We found no association between sodium intake and
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52 204 level of income, however low income bands were underrepresented. This is in contrast to the
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54 205 findings in Hispanic children, where low household income was associated with a greater
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3 206 intake of dietary sodium.⁽³⁷⁾ In a New Zealand food survey, low cost ‘home brand’ labelled
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5 207 food products were found to contain greater quantities of sodium than the more expensive
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7 208 branded food products.⁽³⁸⁾ The impact of income on sodium intake in Australian children
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10 209 remains unclear and further research is required.

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16 211 Previous studies in children have reported socioeconomic differences in the consumption of
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18 212 certain food groups.^(39, 40) For example, in European children of low SES background, greater
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20 213 intake of starchy foods, meat products, savoury snacks such as hamburgers, sugar and
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22 214 confectionary, pizza, desserts and soft drinks have been reported.^(39, 40) In the present study
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24 215 those food groups which were found to contribute more sodium to the diets of low SES
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26 216 children tended to include convenience style foods (i.e. pies/sausage rolls; savoury sauce and
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28 217 casserole base sauces; fried prepared potato; processed meat; potato snacks). Comparably,
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30 218 children of high SES background consumed greater amounts of sodium from cake and baked
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32 219 type products. However, a significant amount of sodium in baked products can be in sodium
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34 220 bicarbonate rather than in the form of sodium chloride. Sodium bicarbonate, unlike sodium
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36 221 chloride, has not been directly associated with adverse blood pressure outcomes.⁽⁴¹⁾

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44 223 With reference to sodium intake data by age group⁽⁵⁾ and comparison to the recommended
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46 224 daily Upper Limit of sodium⁽⁶⁾ it is evident that Australian children of all ages across all SES
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48 225 backgrounds are consuming too much dietary sodium. However, for the first time our
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50 226 findings indicate that socioeconomic disparities exist in sodium intake in Australian children
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52 227 aged 9-13 years. To reduce sodium intake in children a comprehensive approach is required,
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54 228 firstly targeting food policy, to encourage product reformulation of lower sodium food

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3 229 products across all price ranges within the food supply. Secondly, consumer education and
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5 230 awareness campaigns, that encourage food choices which are based on fresh products with
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7 231 minimal processing; this may require strategies that equip parents with enhanced food
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9 232 preparation skills and knowledge of the 'hidden' salt added to many commonly eaten
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11 233 processed foods. Furthermore, it is apparent that these strategies need to reach lower SES
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13 234 groups.
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20 236 The major strengths of this study include the use of a large nationally-representative sample
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22 237 of Australian children, with comprehensive and standardised collection of dietary intake.
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24 238 Limitations of the study include the use of a 24-hr dietary recall to assess sodium intake.

25 239 Firstly, this method ~~which~~ fails to capture the amount of salt coming from salt added at the

26 240 table and during cooking and therefore is likely to underestimate the true value of salt

27 241 intake.⁽⁴²⁾ The majority (77%) of dietary sodium consumed is from salt added to processed

28 242 foods, whilst a smaller amount (11%) has been found to be derived from salt added at the

29 243 table and during cooking.⁽⁴³⁾ In the present study, the higher intake of sodium reported in

30 244 children from low SES background is attributable to differences in sodium intake from food

31 245 sources only. In a previous analysis of ~~these is~~ data, we found that children from low SES

32 246 background (~~3325~~%) were more likely to report adding salt at the table than children from

33 247 high SES (~~2533~~%).⁽²⁶⁾ Thus, it is likely that children of low SES background are consuming

34 248 greater amounts of total daily sodium than reported in the present analysis. Secondly,

35 249 assessment of sodium intake is limited by the quality of food composition databases, which

36 250 may not capture the variation in sodium content of different brand products within each food

37 251 group. ^(42, 44)

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3 253 | In summary, the findings of higher salt intakes from food sources in children of lower SES
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5 254 background, within in a nationally representative sample, provides focus for concern
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7 255 regarding salt related disease across the life course. This socioeconomic patterning of salt
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9 256 intake may in turn influence the SES disparity seen in hypertension and cardiovascular risk in
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11 257 adulthood. To reduce socioeconomic inequalities in health, interventions need to begin early
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13 258 in life and should include product reformulation of lower sodium food products across all
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15 259 price ranges, as well as consumer education and awareness campaigns which reach low SES
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17 260 groups.
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24 262 **Contributorship statement:** The author's responsibilities were as follows – CAG, KJC, LJR
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26 263 and CAN designed research; CAG performed statistical analysis and wrote the manuscript
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28 264 and is guarantor of the paper; LJR, KJC and CAN helped with data interpretation, revision of
29
30 265 manuscript and provided significant consultation. All authors have read and approved the
31
32 266 final manuscript.
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37
38 268 Foundation of Australia PP 08M 4074.
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Table 1. Basic characteristics of Australian children and adolescents aged 2-16 years (n 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

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‡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)

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3 **Figure 1.** Mean sodium intake (mg/d) by socioeconomic group (n = 4487)^{†‡}
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18 * Significantly different from high SES ($P < 0.001$)
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21 ** Significantly different from high SES ($P < 0.05$)
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24 †SES as defined by the highest level of education attained by the primary carer
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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†			P value‡
		Low (n 1414)	Mid (n 1583)	High (n 1490)	
	% 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

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5 products and dishes
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8 ¶ Includes those sub-major food group categories that contribute >1.0% of sodium to daily intake ambiguous
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11 †SES as defined by the highest level of education attained by the primary carer
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14 ‡Means are compared between low and high SES groups using independent T-test
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17 §includes ham, bacon and processed delicatessen meat
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20 □includes pasta sauces and casserole bases
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23 ¶includes pies and sausage rolls
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26 ¶ ¶ includes potato gems and wedges
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29 ††includes pancakes and pikelets
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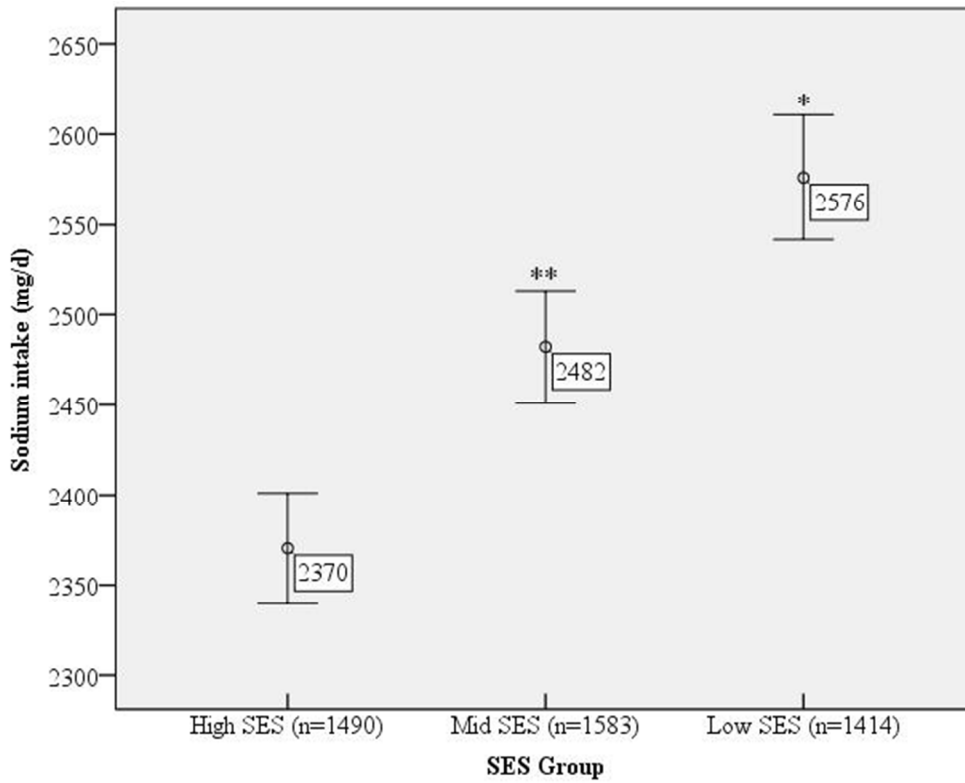
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* Significantly different from high SES (P <0.001)
** Significantly different from high SES (P <0.05)
†SES as defined by the highest level of education attained by the primary carer
220x176mm (72 x 72 DPI)

View only

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) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —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 <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants (b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —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) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy (e) Describe any sensitivity analyses

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60**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) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time <i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure <i>Cross-sectional study</i> —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
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*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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Primary Subject Heading:	Public health
Secondary Subject Heading:	Paediatrics, Cardiovascular medicine, Epidemiology, Nutrition and metabolism
Keywords:	NUTRITION & DIETETICS, Community child health < PAEDIATRICS, EPIDEMIOLOGY

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Manuscripts

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3 **Is socioeconomic status associated with dietary sodium intake in Australian children? A**
4 **cross-sectional study**
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8 Carley A. Grimes¹, Karen J Campbell², Lynn J Riddell³, Caryl A. Nowson⁴
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Short title:

Dietary sodium intake and socioeconomic status in Australian children

Key words:

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

Word count: 2651

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All authors have completed the Unified Competing Interest form at www.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.

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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

For peer review only

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2
3 **1 ABSTRACT**
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6 **2 Objective:** To assess the association between socioeconomic status (SES) and dietary sodium
7
8 intake, and identify if the major dietary sources of sodium differ by socioeconomic group in a
9
10 nationally representative sample of Australian children.
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13 **5 Design:** Cross-sectional survey.
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16 **6 Setting:** 2007 Australian National Children's Nutrition and Physical Activity Survey.
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20 **7 Participants:** A total of 4487 children aged 2-16 years completed all components of the
21
22 survey.
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25 **9 Primary and secondary outcome measures:** Sodium intake was determined via one 24-hr
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27 dietary recall. The population proportion formula was used to identify the major sources of
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29 dietary salt. SES was defined by the level of education attained by the primary carer. In
30
31 addition parental income was used as a secondary indicator of SES.
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35 **13 Results:** Dietary sodium intake of children of low SES background was 2576 (SEM 42) mg/d
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37 (salt equivalent 6.6 (0.1) g/d) which was greater than children of high SES background 2370
38
39 (35) mg/d (salt 6.1 (0.09) g/d) ($P<0.001$). After adjustment for age, gender, energy intake
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41 and body mass index, low SES children consumed 195 mg/d (salt 0.5 g/d) more sodium than
42
43 high SES children ($P<0.001$). Low SES children had a greater intake of sodium from
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45 processed meat, gravies/sauces, pastries, breakfast cereals, potatoes and potato snacks (all
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47 $P<0.05$).
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51 **20 Conclusion:** Australian children from a low SES background have on average a 9% greater
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53 intake of sodium from food sources compared to those from a high SES background.
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22 Understanding the socioeconomic patterning of salt intake during childhood should be
23 considered in interventions to reduce cardiovascular disease.

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3 24 **Article summary:**
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6 25 **Article focus**
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9 26 • To assess the association between socioeconomic status (SES) and dietary sodium intake
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11 27 in Australian children and adolescents.
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14 28 • To determine if the major dietary sources of sodium differ by socioeconomic group.
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17 29 **Key messages**
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20 30 • In Australian children socioeconomic status is inversely associated with dietary sodium
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22 31 intake.
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25 32 • Children of low socioeconomic background consumed more sodium from convenience
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27 33 style foods including pies/sausage rolls; savoury sauces, fried prepared potato; processed
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29 34 meat and potato crisps.
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33 35 **Strengths and limitations of this study**
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36 36 • These results are based on a large nationally representative sample of Australian children
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38 37 and adolescents.
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41 38 • Sodium intake was determined via a 24-hr dietary recall and therefore does not capture the
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43 39 amount of sodium derived from salt used at the table or during cooking.
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47 40 The socioeconomic disparity of sodium intake reported in this study is attributable to
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49 41 differences in sodium intake from food sources only. Further research is required to
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51 42 understand how SES impacts on raising sodium intake.
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43 INTRODUCTION

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

63 METHODS

64 Study design

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3 65 The 2007 Australian Children's Nutrition and Physical Activity Survey (CNPAS) was a
4
5 66 cross-sectional survey designed to collect demographic, dietary, anthropometric and physical
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7 67 activity data from a nationally representative sample of children aged 2-16 years. The full
8
9 68 details of the sampling methodology can be found elsewhere.⁽²⁴⁾ Briefly, participants were
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11 69 recruited using a multistage quota sampling framework. The initial target quota was 1000
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13 70 participants for each of the following age groups; 2-3, 4-8, 9-13 and 14-16 years (50% boys
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15 71 and 50% girls), to which a 400 booster sample was later provided by the state of South
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17 72 Australia. The primary sampling unit was postcode and clusters of postcodes were randomly
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19 73 selected as stratified by state/territory and by capital city statistical division or rest of
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21 74 state/territory. Randomly selected clusters of postcodes ensured an equal number of
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23 75 participants in each age group, from each of the metro and non-metro areas within each state.
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25 76 Within selected postcodes Random Digit Dialling (RDD) was used to invite eligible
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27 77 households, i.e. those with children aged 2-16 years, to participate in the study. Only one
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29 78 child from each household could participate in the study. The response rate of eligible
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31 79 children was 40%. Due to the non-proportionate nature of the sampling framework each
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33 80 participant was assigned a population weighting which weighted for age, gender and region.
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35 81 The study was approved by the National Health and Medical Research Council registered
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37 82 Ethics Committees of Commonwealth Scientific and Industrial Research Organisation and
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39 83 the University of South Australia. All participants, or where the child was aged <14 years the
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41 84 primary carer, provided written consent.⁽²⁴⁾
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51 **Assessments**

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54 87 Demographic and food intake data was collected during a face to face computer assisted
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56 88 personal interview (CAPI) completed during February and August 2007. A three-pass 24 h
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3 89 dietary recall was used to determine all food and beverages consumed from midnight to
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5 90 midnight on the day prior to the interview.⁽²⁴⁾ The three pass method includes the following
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7 91 stages i) provide a quick list of all foods and beverages ii) a series of probe questions relevant
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10 92 to each quick list item to gather more detailed information on time and place of consumption,
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12 93 any additions to the food item, portion size and brand name iii) finally, a recall review to
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14 94 validate information and make any necessary adjustments. Portion sizes were estimated
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16 95 using a validated food model booklet and standard household measures. To minimise error
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18 96 after data collection all interviews were reviewed by study dietitians to assess for unrealistic
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21 97 portion sizes, inadequate detail and typing errors. The primary carer of participants aged 9
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23 98 years and under provided information on dietary intake.⁽²⁴⁾
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29 100 Sodium intake was calculated using the Australian nutrient composition database
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31 101 AUSNUT2007, specifically developed by the Food Standards Australia and New Zealand for
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33 102 the CNPAS.⁽²⁵⁾ A description of the food coding system using in this database has previously
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35 103 been described.⁽²⁶⁾ Daily sodium (mg) intake was converted to the salt equivalent (g) using
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37 104 the conversion 1 gram of sodium chloride (salt) = 390 mg sodium. Reported salt intake did
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39 105 not include salt added at the table or during cooking.
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46 107 *Indicator of socioeconomic status*
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49 108 Consistent with other dietary studies in children and adolescents we have used level of
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51 109 education attained by the primary carer and household income as markers of SES.^(27,28) The
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53 110 highest level of education attained by the primary carer was used to define SES. Based on
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56 111 this participants were grouped into one of three categories of SES; i) high: includes those
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3 112 with a university/tertiary qualification ii) mid: includes those with an advanced diploma,
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5 113 diploma or certificate III/IV or trade certificate iii) low: includes those with some or no level
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7 114 of high school education. Parental income was used as a secondary indicator of SES.
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9 115 Reported parental income before tax was grouped into four categories i) AUD\$ 0 to \$31 999
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11 116 ii) \$31 200 to \$51 999 iii) \$52 000 to \$103 999 iv) \geq \$104 000. Body weight and height were
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13 117 measured using standardised protocols.⁽²⁹⁾ BMI was calculated as body weight (kg) divided
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15 118 by the square of body height (m²). Participants were grouped into weight categories (very
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17 119 underweight, underweight, healthy weight, overweight, obese) using the International
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19 120 Obesity Task Force BMI reference cut offs for children.^(30,31)
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27 122 **Statistical analysis**

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30 123 Statistical analyses were completed using STATA/SE 11 (StataCorp, College Station, Texas
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32 124 USA) and PASW Statistics 17.0 (PASW Inc, Chicago, IL, USA). A *P* value of <0.05 was
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34 125 considered significant. All analyses accounted for the complex survey design using the
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36 126 STATA svy command, specifying strata variable (region), cluster variable (post code) and
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38 127 population weighting (age, gender, region). Descriptive statistics are presented as mean (SD)
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40 128 or n (% weighted). Pearson correlation coefficient was used to assess the association
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42 129 between sodium intake, energy intake and BMI. To assess the association between SES, as
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44 130 defined by primary carer education level, and sodium intake, multiple regression analysis was
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46 131 used with adjustment for age, gender, energy intake and BMI. To further control for the
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48 132 effects of age, the analysis was repeated stratified by age group (i.e. 2-3; 4-8; 9-13; 14-16
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50 133 years). These age categories are consistent with those used in Australian dietary guidelines
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52 134 ⁽⁶⁾. As income level is sometimes used as a marker of SES ⁽¹³⁾ the association between
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3 135 parental income and sodium intake was also examined, with adjustment for age, gender,
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5 136 energy intake and BMI. The regression coefficient (β) with 95% CI, corresponding *P* values
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7 137 and the coefficient of determination (R^2) are presented. In a previous analysis⁽²⁶⁾ which
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9 138 included the same study population we used the population proportion formula⁽³²⁾ to calculate
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11 139 the contribution of sodium from sub-major food group categories, as defined in the CNPAS
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13 140 food group coding system.⁽²⁴⁾ The population proportion formula⁽³²⁾ is outlined below:

14 141 **% of sodium from food group** = [sum of sodium from food group (mg) / total sum of
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17 142 sodium from all foods (mg)] X 100

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23 143 For the present study, we have utilised this list which identifies the main sources of dietary
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25 144 sodium, to determine if sodium intake from food group differs between low and high SES
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27 145 categories, based on primary carer education level. To do this, we calculated the mean
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29 146 sodium intake from each sub-major food group by SES category, and compared the mean
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31 147 sodium of low to high SES, using an independent T-test.
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36 37 38 149 **RESULTS**

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41 150 Basic characteristics of the 4 487 participants are listed in **Table 1**. As defined by parental
42
43 151 education status, the proportion of children from low, mid and high SES background was
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45 152 relatively evenly distributed. Over two thirds of children fell within the two highest income
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47 153 bands. There was a significant positive correlation between sodium intake and energy intake
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49 154 ($r = 0.69$, $P < 0.001$) and sodium intake and BMI ($r = 0.22$, $P < 0.001$). Average daily sodium
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51 155 intake differed by SES (**Figure 1**, $P < 0.01$). Regression analysis indicated that low SES was
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53 156 associated with a 195 mg/d (salt 0.5 g/d) greater intake of sodium. The association between
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3 157 SES and sodium intake remained after adjustment for age, gender, energy intake and BMI
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5 158 (**Table 2**). When stratified by age group the association between sodium intake and SES
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7 159 remained significant between the ages of 4-13 years (**Table 2**), however there was no
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10 160 association between sodium intake and SES in 2-3 year olds or in 14-16 year olds (data not
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12 161 shown). There was no association between sodium intake and parental income (data not
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14 162 shown), however, only 28% of children fell within the two lowest income bands (**Table 1**)
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20 164 **Table 3** lists those sub-major food groups which contributed >1% to the groups' total daily
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22 165 sodium intake. Combined these 23 food groups accounted for 84.5% of total daily sodium
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24 166 intake. Regular breads and bread rolls contributed the most sodium. Moderate sources of
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26 167 sodium, contributing more than 4% of total sodium intake, included mixed dishes where
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28 168 cereal is the major ingredient (e.g. pizza, hamburger, sandwich, savoury rice and noodle
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30 169 based dishes), processed meat, gravies and savoury sauces, pastries, cheese, and breakfast
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32 170 cereals and bars. Compared to children of high SES, children of low SES had a significantly
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34 171 greater intake of sodium from processed meat, gravies and savoury sauce, pastries, breakfast
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36 172 cereals and bars, potatoes and potato snacks (e.g. potato crisps). The percentage difference in
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38 173 sodium intake in each of these categories was 46%, 31%, 24%, 16%, 39% and 46%,
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40 174 respectively (**Table 3**). Conversely, children of high SES background had a significantly
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42 175 greater intake of sodium from the food group containing cakes, buns, muffins, scones, cake-
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44 176 type desserts; and the food group described as batter-based products (e.g. pancakes, picklets).
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46 177 The percentage difference in sodium intake in each of these categories was 16% and 32%,
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48 178 respectively (**Table 3**).
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3 180 **DISCUSSION**
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6 181 In a nationally representative sample of Australian children aged 2-16 years, we found
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8 182 children of low SES background consumed 9% more dietary sodium, from food sources, than
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10 183 those of high SES background. The inverse association between sodium intake and SES was
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12 184 primarily driven by the association in children aged 4-13 years, particularly after adjustment
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14 185 for the important covariates age, gender, energy intake and BMI. In adult studies, low SES
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16 186 has been associated with more frequent consumption of high salt foods, such as soup, sauces,
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18 187 ready to eat meals, savoury seasonings, sausages and potato.^(33, 34) Given parental control
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20 188 over children's food choices during these years, it is likely that SES disparities in adult food
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22 189 choices relating to high salt foods may filter down into children's eating practices. We found
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24 190 no association between SES and sodium intake in 2-3 and 14-16 year olds. Although some
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26 191 evidence indicates SES disparities in dietary patterns may be present during infancy,⁽³⁵⁾ it is
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28 192 possible such early differences are not seen in dietary patterns with the restricted range of
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30 193 food types. In the case of adolescents, as autonomy over food choices increases, other
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32 194 factors, such as peer-influence, taste and eating away from the home⁽³⁶⁾ may become more
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34 195 prominent determinants of dietary intake.
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43 197 Using US National Health and Nutrition Examination Survey (NHANES) data, Mazur et
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45 198 al.⁽³⁷⁾ explored the association of SES, as indicated by head of household education status and
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47 199 household income, on sodium intake in Hispanic children aged 4-16 years. Interestingly, in
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49 200 this study lower levels of education were associated with lower sodium intake⁽³⁷⁾. This is
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51 201 contrary to our own findings as well as past studies, which generally link lower SES to
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53 202 overall poorer dietary outcomes.⁽¹³⁾ We found no association between sodium intake and
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55 203 level of income, however low income bands were underrepresented. This is in contrast to the
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3 204 findings in Hispanic children, where low household income was associated with a greater
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5 205 intake of dietary sodium.⁽³⁷⁾ In a New Zealand food survey, low cost ‘home brand’ labelled
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7 206 food products were found to contain greater quantities of sodium than the more expensive
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9 207 branded food products.⁽³⁸⁾ The impact of income on sodium intake in Australian children
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11 208 remains unclear and further research is required.
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18 210 Previous studies in children have reported socioeconomic differences in the consumption of
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20 211 certain food groups.^(39,40) For example, in European children of low SES background, greater
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22 212 intake of starchy foods, meat products, savoury snacks such as hamburgers, sugar and
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24 213 confectionary, pizza, desserts and soft drinks have been reported.^(39,40) In the present study
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26 214 those food groups which were found to contribute more sodium to the diets of low SES
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28 215 children tended to include convenience style foods (i.e. pies/sausage rolls; savoury sauce and
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30 216 casserole base sauces; fried prepared potato; processed meat; potato snacks). Comparably,
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32 217 children of high SES background consumed greater amounts of sodium from cake and baked
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34 218 type products. However, a significant amount of sodium in baked products can be in sodium
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36 219 bicarbonate rather than in the form of sodium chloride. Sodium bicarbonate, unlike sodium
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38 220 chloride, has not been directly associated with adverse blood pressure outcomes.⁽⁴¹⁾
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46 222 With reference to sodium intake data by age group⁽⁵⁾ and comparison to the recommended
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48 223 daily Upper Limit of sodium⁽⁶⁾ it is evident that Australian children of all ages across all SES
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50 224 backgrounds are consuming too much dietary sodium. However, for the first time our
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52 225 findings indicate that socioeconomic disparities exist in sodium intake in Australian children
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54 226 aged 9-13 years. To reduce sodium intake in children a comprehensive approach is required,
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3 227 firstly targeting food policy, to encourage product reformulation of lower sodium food
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5 228 products across all price ranges within the food supply. Secondly, consumer education and
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7 229 awareness campaigns, that encourage food choices which are based on fresh products with
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10 230 minimal processing; this may require strategies that equip parents with enhanced food
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12 231 preparation skills and knowledge of the 'hidden' salt added to many commonly eaten
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14 232 processed foods. Furthermore, it is apparent that these strategies need to reach lower SES
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16 233 groups.
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22 235 The major strengths of this study include the use of a large nationally-representative sample
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24 236 of Australian children, with comprehensive and standardised collection of dietary intake.
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26 237 Limitations of the study include the use of a 24-hr dietary recall to assess sodium intake.
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29 238 Firstly, this method fails to capture the amount of salt coming from salt added at the table and
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31 239 during cooking and therefore is likely to underestimate the true value of salt intake.⁽⁴²⁾ The
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33 240 majority (77%) of dietary sodium consumed is from salt added to processed foods, whilst a
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35 241 smaller amount (11%) has been found to be derived from salt added at the table and during
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37 242 cooking.⁽⁴³⁾ In the present study, the higher intake of sodium reported in children from low
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39 243 SES background is attributable to differences in sodium intake from food sources only. In a
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41 244 previous analysis of these data, we found that children from low SES background (33%) were
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43 245 more likely to report adding salt at the table than children from high SES (25%).⁽²⁶⁾ Thus, it
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45 246 is likely that children of low SES background are consuming greater amounts of total daily
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47 247 sodium than reported in the present analysis. Secondly, assessment of sodium intake is
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49 248 limited by the quality of food composition databases, which may not capture the variation in
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51 249 sodium content of different brand products within each food group.^(42, 44)
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3 251 In summary, the findings of higher salt intakes from food sources in children of lower SES
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5 252 background, within in a nationally representative sample, provides focus for concern
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7 253 regarding salt related disease across the life course. This socioeconomic patterning of salt
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9 254 intake may in turn influence the SES disparity seen in hypertension and cardiovascular risk in
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11 255 adulthood. To reduce socioeconomic inequalities in health, interventions need to begin early
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13 256 in life and should include product reformulation of lower sodium food products across all
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15 257 price ranges, as well as consumer education and awareness campaigns which reach low SES
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18 258 groups.
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25 260 **Contributorship statement:** The author's responsibilities were as follows – CAG, KJC, LJR
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27 261 and CAN designed research; CAG performed statistical analysis and wrote the manuscript
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29 262 and is guarantor of the paper; LJR, KJC and CAN helped with data interpretation, revision of
30
31 263 manuscript and provided significant consultation. All authors have read and approved the
32
33 264 final manuscript.
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38 266 Foundation of Australia PP 08M 4074.
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Table 1. Basic characteristics of Australian children and adolescents aged 2-16 years (n 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)

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3 **Figure 1.** Mean sodium intake (mg/d) by socioeconomic group (n = 4487)^{†‡}
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18 * Significantly different from high SES ($P < 0.001$)
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21 ** Significantly different from high SES ($P < 0.05$)
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24 †SES as defined by the highest level of education attained by the primary carer
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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[§]						

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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†			P value‡
		Low (n 1414)	Mid (n 1583)	High (n 1490)	
	% 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

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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

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5 products and dishes
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8 ¶ Includes those sub-major food group categories that contribute >1.0% of sodium to daily intake ambiguous
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11 †SES as defined by the highest level of education attained by the primary carer
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14 ‡Means are compared between low and high SES groups using independent T-test
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17 §includes ham, bacon and processed delicatessen meat
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20 □includes pasta sauces and casserole bases
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23 ¶includes pies and sausage rolls
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26 ¶ ¶ includes potato gems and wedges
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29 ††includes pancakes and pikelets
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3 **Is socioeconomic status associated with dietary sodium intake in Australian children? A**
4 **cross-sectional study**
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Short title:

Dietary sodium intake and socioeconomic status in Australian children

Key words:

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

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Data sharing statement:

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3 The authors declare that on request all data files are available for analysis from the
4
5 corresponding author at carley.grimes@deakin.edu.au
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For peer review only

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3 1 **ABSTRACT**
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6 2 **Objective:** To assess the association between socioeconomic status (SES) and dietary sodium
7
8 3 intake, and identify if the major dietary sources of sodium differ by socioeconomic group in a
9
10 4 nationally representative sample of Australian children.

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13 5 **Design:** Cross-sectional survey.
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16 6 **Setting:** 2007 Australian National Children's Nutrition and Physical Activity Survey.
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19 7 **Participants:** A total of 4487 children aged 2-16 years completed all components of the
20
21 8 survey.
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24 9 **Primary and secondary outcome measures:** Sodium intake was determined via one 24-hr
25
26 10 dietary recall. The population proportion formula was used to identify the major sources of
27
28 11 dietary salt. SES was defined by the level of education attained by the primary carer. In
29
30 12 addition parental income was used as a secondary indicator of SES.
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33
34 13 **Results:** Dietary sodium intake of children of low SES background was 2576 (SEM 42) mg/d
35
36 14 (salt equivalent 6.6 (0.1) g/d) which was greater than children of high SES background 2370
37
38 15 (35) mg/d (salt 6.1 (0.09) g/d) ($P<0.001$). After adjustment for age, gender, energy intake
39
40 16 and body mass index, low SES children consumed 195 mg/d (salt 0.5 g/d) more sodium than
41
42 17 high SES children ($P<0.001$). Low SES children had a greater intake of sodium from
43
44 18 processed meat, gravies/sauces, pastries, breakfast cereals, potatoes and potato snacks (all
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46 19 $P<0.05$).
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50 20 **Conclusion:** Australian children from a low SES background have on average a 9% greater
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52 21 intake of sodium from food sources compared to those from a high SES background.
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3 22 Understanding the socioeconomic patterning of salt intake during childhood should be
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5 23 considered in interventions to reduce cardiovascular disease.
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3 24 **Article summary:**
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6 25 **Article focus**
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- 9 • To assess the association between socioeconomic status (SES) and dietary sodium intake
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11 in Australian children and adolescents.
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14 • To determine if the major dietary sources of sodium differ by socioeconomic group.
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17 29 **Key messages**
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- 20 • In Australian children socioeconomic status is inversely associated with dietary sodium
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22 intake.
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25 • Children of low socioeconomic background consumed more sodium from convenience
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27 style foods including pies/sausage rolls; savoury sauces, fried prepared potato; processed
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29 meat and potato crisps.
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33 35 **Strengths and limitations of this study**
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- 36 • These results are based on a large nationally representative sample of Australian children
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38 and adolescents.
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41 • Sodium intake was determined via a 24-hr dietary recall and therefore does not capture the
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43 amount of sodium derived from salt used at the table or during cooking.
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47 The socioeconomic disparity of sodium intake reported in this study is attributable to
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49 differences in sodium intake from food sources only. Further research is required to
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51 understand how SES impacts on raising sodium intake.
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43 INTRODUCTION

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

63 METHODS

64 Study design

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3 65 The 2007 Australian Children's Nutrition and Physical Activity Survey (CNPAS) was a
4
5 66 cross-sectional survey designed to collect demographic, dietary, anthropometric and physical
6
7 67 activity data from a nationally representative sample of children aged 2-16 years. The full
8
9 68 details of the sampling methodology can be found elsewhere.⁽²⁴⁾ Briefly, participants were
10
11 69 recruited using a multistage quota sampling framework. The initial target quota was 1000
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13 70 participants for each of the following age groups; 2-3, 4-8, 9-13 and 14-16 years (50% boys
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15 71 and 50% girls), to which a 400 booster sample was later provided by the state of South
16
17 72 Australia. The primary sampling unit was postcode and clusters of postcodes were randomly
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19 73 selected as stratified by state/territory and by capital city statistical division or rest of
20
21 74 state/territory. Randomly selected clusters of postcodes ensured an equal number of
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23 75 participants in each age group, from each of the metro and non-metro areas within each state.
24
25 76 Within selected postcodes Random Digit Dialling (RDD) was used to invite eligible
26
27 77 households, i.e. those with children aged 2-16 years, to participate in the study. Only one
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29 78 child from each household could participate in the study. The response rate of eligible
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31 79 children was 40%. Due to the non-proportionate nature of the sampling framework each
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33 80 participant was assigned a population weighting which weighted for age, gender and region.
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35 81 The study was approved by the National Health and Medical Research Council registered
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37 82 Ethics Committees of Commonwealth Scientific and Industrial Research Organisation and
38
39 83 the University of South Australia. All participants, or where the child was aged <14 years the
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41 84 primary carer, provided written consent.⁽²⁴⁾
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51 **Assessments**

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54 87 Demographic and food intake data was collected during a face to face computer assisted
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56 88 personal interview (CAPI) completed during February and August 2007. A three-pass 24 h
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89 dietary recall was used to determine all food and beverages consumed from midnight to
90 midnight on the day prior to the interview.⁽²⁴⁾ The three pass method includes the following
91 stages i) provide a quick list of all foods and beverages ii) a series of probe questions relevant
92 to each quick list item to gather more detailed information on time and place of consumption,
93 any additions to the food item, portion size and brand name iii) finally, a recall review to
94 validate information and make any necessary adjustments. Portion sizes were estimated
95 using a validated food model booklet and standard household measures. To minimise error
96 after data collection all interviews were reviewed by study dietitians to assess for unrealistic
97 portion sizes, inadequate detail and typing errors. The primary carer of participants aged 9
98 years and under provided information on dietary intake.⁽²⁴⁾

99

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

106

107 *Indicator of socioeconomic status*

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

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3 112 with a university/tertiary qualification ii) mid: includes those with an advanced diploma,
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5 113 diploma or certificate III/IV or trade certificate iii) low: includes those with some or no level
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7 114 of high school education. Parental income was used as a secondary indicator of SES.
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9 115 Reported parental income before tax was grouped into four categories i) AUD\$ 0 to \$31 999
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11 116 ii) \$31 200 to \$51 999 iii) \$52 000 to \$103 999 iv) \geq \$104 000. Body weight and height were
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13 117 measured using standardised protocols.⁽²⁹⁾ BMI was calculated as body weight (kg) divided
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15 118 by the square of body height (m²). Participants were grouped into weight categories (very
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17 119 underweight, underweight, healthy weight, overweight, obese) using the International
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19 120 Obesity Task Force BMI reference cut offs for children.^(30,31)
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27 122 **Statistical analysis**

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30 123 Statistical analyses were completed using STATA/SE 11 (StataCorp, College Station, Texas
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32 124 USA) and PASW Statistics 17.0 (PASW Inc, Chicago, IL, USA). A *P* value of <0.05 was
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34 125 considered significant. All analyses accounted for the complex survey design using the
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36 126 STATA svy command, specifying strata variable (region), cluster variable (post code) and
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38 127 population weighting (age, gender, region). Descriptive statistics are presented as mean (SD)
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40 128 or n (% weighted). Pearson correlation coefficient was used to assess the association
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42 129 between sodium intake, energy intake and BMI. To assess the association between SES, as
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44 130 defined by primary carer education level, and sodium intake, multiple regression analysis was
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46 131 used with adjustment for age, gender, energy intake and BMI. To further control for the
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48 132 effects of age, the analysis was repeated stratified by age group (i.e. 2-3; 4-8; 9-13; 14-16
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50 133 years). These age categories are consistent with those used in Australian dietary guidelines
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52 134 ⁽⁶⁾. As income level is sometimes used as a marker of SES ⁽¹³⁾ the association between
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3 135 parental income and sodium intake was also examined, with adjustment for age, gender,
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5 136 energy intake and BMI. The regression coefficient (β) with 95% CI, corresponding P values
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7 137 and the coefficient of determination (R^2) are presented. In a previous analysis⁽²⁶⁾ which
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9 138 included the same study population we used the population proportion formula⁽³²⁾ to calculate
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11 139 the contribution of sodium from sub-major food group categories, as defined in the CNPAS
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13 140 food group coding system.⁽²⁴⁾ The population proportion formula⁽³²⁾ is outlined below:

14 141 **% of sodium from food group** = [sum of sodium from food group (mg) / total sum of
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17 142 sodium from all foods (mg)] X 100

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23 143 For the present study, we have utilised this list which identifies the main sources of dietary
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25 144 sodium, to determine if sodium intake from food group differs between low and high SES
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27 145 categories, based on primary carer education level. To do this, we calculated the mean
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29 146 sodium intake from each sub-major food group by SES category, and compared the mean
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31 147 sodium of low to high SES, using an independent T-test.
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36 37 38 149 **RESULTS**

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41 150 Basic characteristics of the 4 487 participants are listed in **Table 1**. As defined by parental
42
43 151 education status, the proportion of children from low, mid and high SES background was
44
45 152 relatively evenly distributed. Over two thirds of children fell within the two highest income
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47 153 bands. There was a significant positive correlation between sodium intake and energy intake
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49 154 ($r = 0.69$, $P < 0.001$) and sodium intake and BMI ($r = 0.22$, $P < 0.001$). Average daily sodium
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51 155 intake differed by SES (**Figure 1**, $P < 0.01$). Regression analysis indicated that low SES was
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53 156 associated with a 195 mg/d (salt 0.5 g/d) greater intake of sodium. The association between
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3 157 SES and sodium intake remained after adjustment for age, gender, energy intake and BMI
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5 158 (**Table 2**). When stratified by age group the association between sodium intake and SES
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7 159 remained significant between the ages of 4-13 years (**Table 2**), however there was no
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10 160 association between sodium intake and SES in 2-3 year olds or in 14-16 year olds (data not
11
12 161 shown). There was no association between sodium intake and parental income (data not
13
14 162 shown), however, only 28% of children fell within the two lowest income bands (**Table 1**)
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20 164 **Table 3** lists those sub-major food groups which contributed >1% to the groups' total daily
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22 165 sodium intake. Combined these 23 food groups accounted for 84.5% of total daily sodium
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24 166 intake. Regular breads and bread rolls contributed the most sodium. Moderate sources of
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26 167 sodium, contributing more than 4% of total sodium intake, included mixed dishes where
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28 168 cereal is the major ingredient (e.g. pizza, hamburger, sandwich, savoury rice and noodle
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30 169 based dishes), processed meat, gravies and savoury sauces, pastries, cheese, and breakfast
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32 170 cereals and bars. Compared to children of high SES, children of low SES had a significantly
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34 171 greater intake of sodium from processed meat, gravies and savoury sauce, pastries, breakfast
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36 172 cereals and bars, potatoes and potato snacks (e.g. potato crisps). The percentage difference in
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38 173 sodium intake in each of these categories was 46%, 31%, 24%, 16%, 39% and 46%,
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40 174 respectively (**Table 3**). Conversely, children of high SES background had a significantly
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42 175 greater intake of sodium from the food group containing cakes, buns, muffins, scones, cake-
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44 176 type desserts; and the food group described as batter-based products (e.g. pancakes, picklets).
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46 177 The percentage difference in sodium intake in each of these categories was 16% and 32%,
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48 178 respectively (**Table 3**).
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3 180 **DISCUSSION**
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6 181 In a nationally representative sample of Australian children aged 2-16 years, we found
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8 182 children of low SES background consumed 9% more dietary sodium, from food sources, than
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10 183 those of high SES background. The inverse association between sodium intake and SES was
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12 184 primarily driven by the association in children aged 4-13 years, particularly after adjustment
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14 185 for the important covariates age, gender, energy intake and BMI. In adult studies, low SES
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16 186 has been associated with more frequent consumption of high salt foods, such as soup, sauces,
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18 187 ready to eat meals, savoury seasonings, sausages and potato.^(33, 34) Given parental control
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20 188 over children's food choices during these years, it is likely that SES disparities in adult food
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22 189 choices relating to high salt foods may filter down into children's eating practices. We found
23
24 190 no association between SES and sodium intake in 2-3 and 14-16 year olds. Although some
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26 191 evidence indicates SES disparities in dietary patterns may be present during infancy,⁽³⁵⁾ it is
27
28 192 possible such early differences are not seen in dietary patterns with the restricted range of
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30 193 food types. In the case of adolescents, as autonomy over food choices increases, other
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32 194 factors, such as peer-influence, taste and eating away from the home⁽³⁶⁾ may become more
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34 195 prominent determinants of dietary intake.
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43 197 Using US National Health and Nutrition Examination Survey (NHANES) data, Mazur et
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45 198 al.⁽³⁷⁾ explored the association of SES, as indicated by head of household education status and
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47 199 household income, on sodium intake in Hispanic children aged 4-16 years. Interestingly, in
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49 200 this study lower levels of education were associated with lower sodium intake⁽³⁷⁾. This is
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51 201 contrary to our own findings as well as past studies, which generally link lower SES to
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53 202 overall poorer dietary outcomes.⁽¹³⁾ We found no association between sodium intake and
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55 203 level of income, however low income bands were underrepresented. This is in contrast to the
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3 204 findings in Hispanic children, where low household income was associated with a greater
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5 205 intake of dietary sodium.⁽³⁷⁾ In a New Zealand food survey, low cost ‘home brand’ labelled
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7 206 food products were found to contain greater quantities of sodium than the more expensive
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9 207 branded food products.⁽³⁸⁾ The impact of income on sodium intake in Australian children
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11 208 remains unclear and further research is required.
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18 210 Previous studies in children have reported socioeconomic differences in the consumption of
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20 211 certain food groups.^(39, 40) For example, in European children of low SES background, greater
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22 212 intake of starchy foods, meat products, savoury snacks such as hamburgers, sugar and
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24 213 confectionary, pizza, desserts and soft drinks have been reported.^(39, 40) In the present study
25
26 214 those food groups which were found to contribute more sodium to the diets of low SES
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28 215 children tended to include convenience style foods (i.e. pies/sausage rolls; savoury sauce and
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30 216 casserole base sauces; fried prepared potato; processed meat; potato snacks). Comparably,
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32 217 children of high SES background consumed greater amounts of sodium from cake and baked
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34 218 type products. However, a significant amount of sodium in baked products can be in sodium
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36 219 bicarbonate rather than in the form of sodium chloride. Sodium bicarbonate, unlike sodium
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38 220 chloride, has not been directly associated with adverse blood pressure outcomes.⁽⁴¹⁾
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46 222 With reference to sodium intake data by age group⁽⁵⁾ and comparison to the recommended
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48 223 daily Upper Limit of sodium⁽⁶⁾ it is evident that Australian children of all ages across all SES
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50 224 backgrounds are consuming too much dietary sodium. However, for the first time our
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52 225 findings indicate that socioeconomic disparities exist in sodium intake in Australian children
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54 226 aged 9-13 years. To reduce sodium intake in children a comprehensive approach is required,
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3 227 firstly targeting food policy, to encourage product reformulation of lower sodium food
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5 228 products across all price ranges within the food supply. Secondly, consumer education and
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7 229 awareness campaigns, that encourage food choices which are based on fresh products with
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9 230 minimal processing; this may require strategies that equip parents with enhanced food
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11 231 preparation skills and knowledge of the 'hidden' salt added to many commonly eaten
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13 232 processed foods. Furthermore, it is apparent that these strategies need to reach lower SES
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15 233 groups.
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22 234
23 235 The major strengths of this study include the use of a large nationally-representative sample
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25 236 of Australian children, with comprehensive and standardised collection of dietary intake.
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27 237 Limitations of the study include the use of a 24-hr dietary recall to assess sodium intake.
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29 238 Firstly, this method fails to capture the amount of salt coming from salt added at the table and
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31 239 during cooking and therefore is likely to underestimate the true value of salt intake.⁽⁴²⁾ The
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33 240 majority (77%) of dietary sodium consumed is from salt added to processed foods, whilst a
34
35 241 smaller amount (11%) has been found to be derived from salt added at the table and during
36
37 242 cooking.⁽⁴³⁾ In the present study, the higher intake of sodium reported in children from low
38
39 243 SES background is attributable to differences in sodium intake from food sources only. In a
40
41 244 previous analysis of these data, we found that children from low SES background (33%) were
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43 245 more likely to report adding salt at the table than children from high SES (25%).⁽²⁶⁾ Thus, it
44
45 246 is likely that children of low SES background are consuming greater amounts of total daily
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47 247 sodium than reported in the present analysis. Secondly, assessment of sodium intake is
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49 248 limited by the quality of food composition databases, which may not capture the variation in
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51 249 sodium content of different brand products within each food group.^(42, 44)
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3 251 In summary, the findings of higher salt intakes from food sources in children of lower SES
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5 252 background, within in a nationally representative sample, provides focus for concern
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7 253 regarding salt related disease across the life course. This socioeconomic patterning of salt
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9 254 intake may in turn influence the SES disparity seen in hypertension and cardiovascular risk in
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11 255 adulthood. To reduce socioeconomic inequalities in health, interventions need to begin early
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13 256 in life and should include product reformulation of lower sodium food products across all
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15 257 price ranges, as well as consumer education and awareness campaigns which reach low SES
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18 258 groups.
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24 260 **Contributorship statement:** The author's responsibilities were as follows – CAG, KJC, LJR
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26 261 and CAN designed research; CAG performed statistical analysis and wrote the manuscript
27
28 262 and is guarantor of the paper; LJR, KJC and CAN helped with data interpretation, revision of
29
30 263 manuscript and provided significant consultation. All authors have read and approved the
31
32 264 final manuscript.
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38 266 Foundation of Australia PP 08M 4074.
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Table 1. Basic characteristics of Australian children and adolescents aged 2-16 years (n 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

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‡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)

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3 **Figure 1.** Mean sodium intake (mg/d) by socioeconomic group (n = 4487)^{†‡}
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18 * Significantly different from high SES ($P < 0.001$)
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21 ** Significantly different from high SES ($P < 0.05$)
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24 †SES as defined by the highest level of education attained by the primary carer
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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†			P value‡
		Low (n 1414)	Mid (n 1583)	High (n 1490)	
	% 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

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5 products and dishes
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8 ¶ Includes those sub-major food group categories that contribute >1.0% of sodium to daily intake ambiguous
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11 †SES as defined by the highest level of education attained by the primary carer
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14 ‡Means are compared between low and high SES groups using independent T-test
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17 §includes ham, bacon and processed delicatessen meat
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20 □includes pasta sauces and casserole bases
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23 ¶includes pies and sausage rolls
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26 ¶ ¶ includes potato gems and wedges
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29 ††includes pancakes and pikelets
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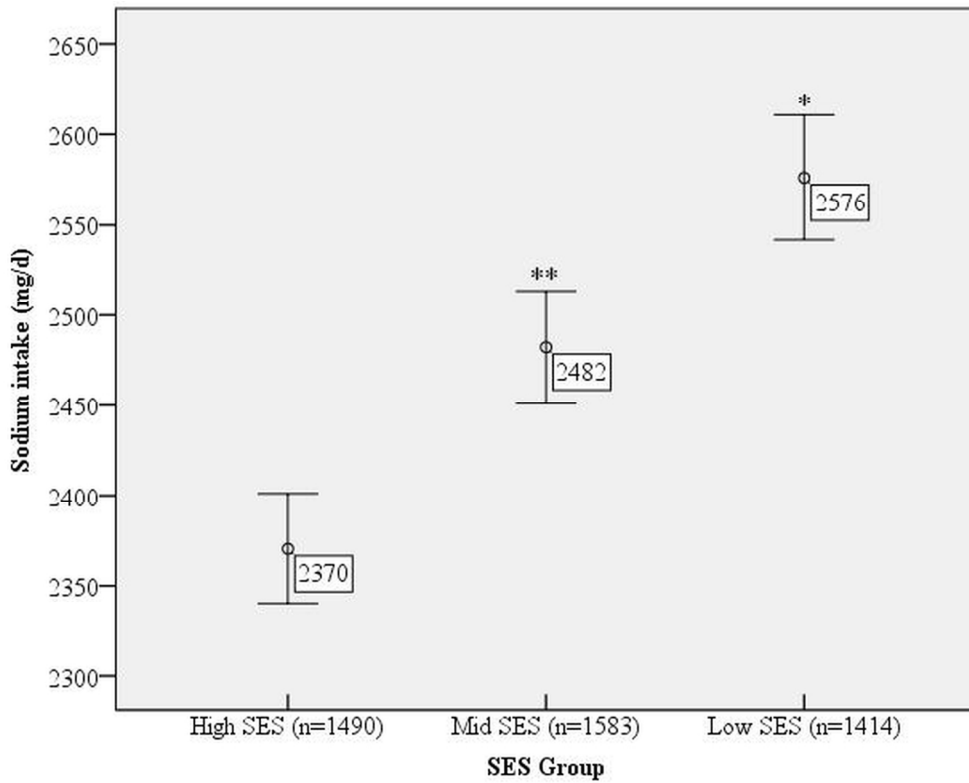
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* Significantly different from high SES (P <0.001)
** Significantly different from high SES (P <0.05)
†SES as defined by the highest level of education attained by the primary carer
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STROBE Statement—checklist 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) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —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 <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants (b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —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) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy (e) Describe any sensitivity analyses

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60**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) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time <i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure <i>Cross-sectional study</i> —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
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*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.