



Short communication

Dietary sources of sodium across the diverse New Zealand adult population

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ABSTRACT

Our aim was to determine dietary sources of sodium for adults in Aotearoa New Zealand (NZ). We used data from the most recent NZ Adult Nutrition Survey (ANS 2008/09) including 4,721 free-living adults aged 15+ years who completed a single 24-hour dietary recall. Population weighted percentage contribution to dietary sodium was calculated and ranked for major and minor food categories across the total population and by gender (male and female), ethnicity (Māori, Pacific, Asian, and Other), and age (15 to 20, 21 to 40, 41 to 60, and 61+ years). Fifteen major food categories contributed ~80% of sodium consumed by the total population; the top five were 'Bread' (18%), 'Bread-based dishes' (11%), 'Grains and pasta' (7%), 'Pork' (7%), and 'Sausages and processed meats' (5%). Compared to other sub-groups within the same demographic, the top-five major sources of sodium specific to Females were 'Soups and stocks', Pacific communities were Poultry, Māori whānau was 'Pork', Others was 'Pork', Asian was 'Soups and stocks' and 'Vegetables', and 61+ years was 'Soups and stocks'. Our findings provide information on the major and minor food sources of sodium for the diverse NZ population. The differences observed in major dietary sources by population subgroup are critical for policymakers to include in the development of any future country-specific sodium reduction targets; repeating the total population approach taken in several other countries is unlikely to improve inequities in heart-related health in NZ.

1. Introduction

Diets high in sodium increase blood pressure (Grillo et al., 2019; He et al., 2013), which in turn raises the risk of heart disease and stroke (Ettehad et al., 2016). However, many countries globally exceed the World Health Organization (WHO) recommended upper intake limit of 2,000 mg of sodium (5 g of salt) per day (World Health Organization, 2013). In 2013 the WHO proposed a target for member states to achieve a 30% relative reduction in population sodium intake by 2025 (World Health Organization, 2013), and at least 96 countries are working towards this target by means of a formal national sodium reduction strategy (Santos et al., 2021; Hyseni et al., 2017).

Similar to other Western countries, adults living in Aotearoa New Zealand (NZ), an ethnically diverse country of approximately 5 million (Statistics New Zealand, 2021; Statistics New Zealand, 2021), consume 40% more sodium than WHO recommendations (3,373 mg/day) (World Health Organization, 2013; Skeaff et al., 2013). One in five NZ adults 15 years and older has high blood pressure, and 177,000 are living with

ischemic heart disease (Ministry of Health, 2019). Furthermore, these conditions are inequitably distributed, with underserved populations including Māori whānau (indigenous New Zealanders) and Pacific communities, suffering a higher burden (Ministry of Health, 2019).

Despite committing to the 2013 WHO sodium reduction target, NZ does not currently have a national sodium reduction strategy and there is a dearth of information on the foods contributing to population sodium intake; this information was not reported in the most recent Adult Nutrition Survey (ANS 2008/09) (The University of Otago and Ministry of Health, 2008). Our aim was to determine the major and minor dietary sources of sodium for adults in Aotearoa NZ.

2. Methods

2.1. Study design and data source

We used secondary data from the ANS 2008/09 (The University of Otago and Ministry of Health, 2008) collected by the Ministry of Health

Abbreviations: ANS, Adult Nutrition Survey; NZ, New Zealand; WHO, World Health Organization.

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and The University of Otago. A full methodology report can be found elsewhere ([The University of Otago, 2008](#)). However, the ANS dataset comprised food and beverage intake volumes for 4,721 free-living adults aged 15 + years who completed a single 24-hour diet recall ([The University of Otago, 2008](#)). The ANS 2008/09 survey design included increased sampling of Māori, Pasifika, and younger and older age groups. Individual survey weights, created using a ‘calibrated weighting’ approach, were provided in the dataset ([The University of Otago, 2008](#)). Ethnic group was allocated using a total response approach where each person is assigned to all ethnicities they identify with. Foods consumed were categorised into 33 major and 343 minor food categories (Appendix A) ([The University of Otago, 2008](#)). While 25% of ANS participants completed a second 24-hour diet recall, consumption in many minor food categories was too sparse to assess usual intake.

2.2. Outcomes

Outcomes were the percentage contribution to dietary sodium from major and minor food categories in the ANS, up to 80% of consumed sodium. The final 20% was excluded because these food categories contributed <3% each to dietary sodium and were assumed outside of the target for intervention. All outcomes were assessed for the total population and by gender (male and female), ethnic group (Māori, Pacific, Asian, and Other), and age group (15 to 20, 21 to 40, 41 to 60, and 61+ years).

2.3. Data preparation and statistical analysis

First, the weighted mean sodium intake for each of the 343 minor food categories was calculated. Authors linked each of the food items recorded in the ANS 2008/09, including recipes broken down into their components, with the NZ food composition tables (10th edition, unpublished data supplied by Otago University Life in New Zealand (LINZ) (personal communication, Blakey, Smith and Parnell, 2014). Foods and recipes which could not be matched to the NZ food composition tables were matched with codes from the most recent prior national nutrition survey i.e., the 2002 Children’s Nutrition Survey ([Ministry of Health, 2003](#)) (personal communication, Blakey, 2020). This matching process provided a sodium value per 100 g for each food.

Next, mean intake in g’s was calculated for each food category using

the per-participant survey weightings provided in the dataset. Total weighted intake for each minor food category for the total population and for each demographic sub-group was then summed and divided by the average survey weighting for that demographic subgroup, thus providing representative food intake data by age, gender, and ethnicity. Intake of the minor food categories was then multiplied by the mean sodium content of that category to estimate average sodium consumed for each minor food category by relevant population sub-group ([The University of Otago, 2008](#)).

Percentage contribution of each category to daily sodium intake was calculated by summing the weighted mean sodium content for each food category and dividing by the total sodium contents of the diet. Mean percentage sodium from each of the 33 major food groups was calculated by summing the sodium contribution by food category. Discretionary salt was not included due to the known difficulties in accurately estimating discretionary salt intake ([Thomson, 2006](#)). All analyses were completed in Stata SE 15.1.

3. Results

The final response rate for the ANS 2008/09 was 61% ([The University of Otago and Ministry of Health, 2008](#)). Appendix Table B1 shows the characteristics of the 4,721 survey respondents. [Table 1](#) shows the percentage contribution of sodium consumed from the major food categories for the total population and by ethnic, gender, and age groups. Appendix Fig. B1, Tables C1-11, and Appendix D show the ranked data for the minor food categories and illustrate charts comparing findings for major food categories by demographic sub-group.

3.1. Total population

Fifteen major food categories contributed 80% of dietary sodium, with the top five providing $\geq 5\%$ each i.e., ‘Bread’ (18.2%), ‘Bread-based dishes’ (10.9%), ‘Grains and pasta’ (6.6%), ‘Pork’ (6.5%), and ‘Sausages and processed meats’ (5.2%; [Fig. 1](#) and [Table 1](#)). For ‘Bread’, White (7.3%) and Mixed grain (5.3%) varieties were the top two minor food category contributors. The corresponding top-ranked minor food category for ‘Bread-based dishes’ was Sandwiches and filled rolls (5.7%), for ‘Grains and pasta’ was Pasta and sauce (2.9%), for ‘Pork’ was Ham

Table 1

Percentage contribution by major food category to the sodium intake of the New Zealand adult population and by sex, ethnicity, and age*.

Major food category**	Total population	Females	Males	Māori	Pacific	Asian	Other ethnicity	15–20 years	21–40 years	41–60 years	61 + years
Bread (includes speciality breads)	18.2%	18.0%	18.4%	19.4%	18.9%	16.9%	18.1%	15.1%	16.4%	19.2%	22.0%
Bread-based dishes	10.9%	8.2%	12.8%	11.1%	10.2%	7.0%	11.1%	18.7%	13.0%	9.3%	4.9%
Grains and Pasta	6.6%	6.3%	6.8%	5.6%	7.6%	18.5%	6.0%	9.6%	8.3%	5.7%	
Pork	6.5%	5.3%	7.3%	6.1%	3.7%	2.5%	7.0%	5.1%	6.0%	7.3%	6.9%
Sausages and processed meats	5.2%	4.9%	5.4%	7.7%	6.5%		4.9%	5.2%	5.4%	5.2%	4.8%
Savoury sauces and condiments	4.6%	5.2%	4.2%	3.7%	3.9%	5.6%	4.7%	4.2%	4.8%	4.6%	4.3%
Soups and stocks	4.0%	5.4%	2.9%	3.2%	3.3%	7.9%	3.9%		3.2%	3.9%	6.6%
Vegetables	4.0%	4.8%	3.4%			9.6%	4.0%		3.7%	4.5%	4.5%
Cheese	4.0%	4.3%	3.7%				4.5%	3.2%	3.6%	4.6%	3.9%
Milk	3.7%	4.2%	3.4%	3.0%	2.8%	4.1%	3.9%	3.0%		4.3%	4.7%
Cakes and muffins	3.3%	3.9%				2.7%	3.5%		3.1%	3.3%	4.2%
Poultry	3.3%	3.3%	3.3%	3.6%	5.3%	3.6%	3.1%	3.9%	3.5%	3.3%	
Pies and pasties	3.1%	3.4%	4.6%	4.1%				3.1%	3.8%		
Potatoes, kumara and taro	3.0%	2.9%	3.1%	3.9%	3.6%		2.9%	4.2%	3.2%		
Fish and Seafood		3.2%		4.0%	5.2%	3.4%				3.7%	
Breakfast cereals			3.0%				2.9%	2.8%			3.9%
Butter and Margarine				2.7%	2.7%						
Non-alcoholic beverages				3.1%	3.3%			3.5%			

*Adult = 15 years and older. ** High level food groups are drawn from the 33 high level food groups in the 2008/09 New Zealand Adult Nutrition Survey. Food groups are included if they are in the top 80% of contributions to sodium in the diet.

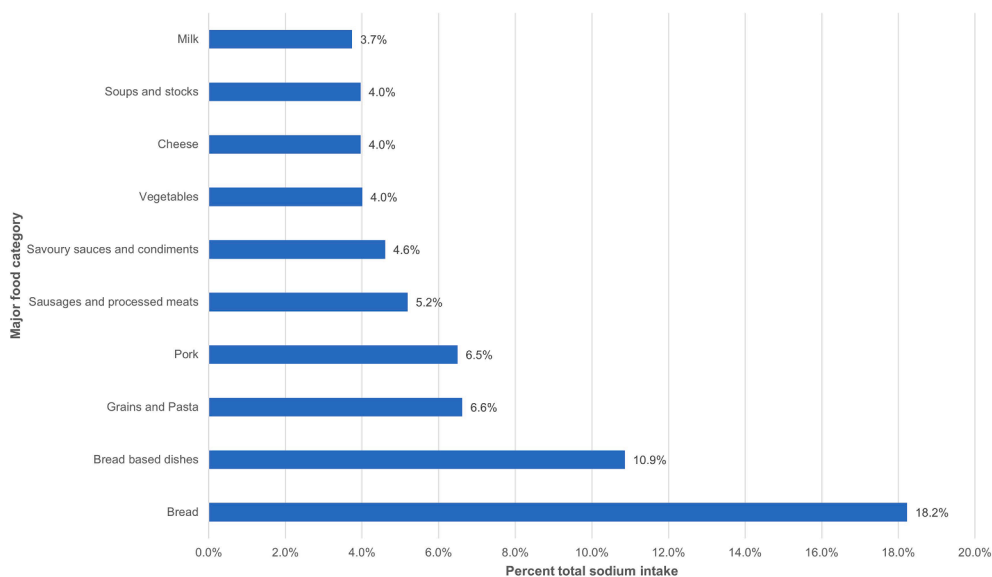


Fig. 1. Top 10 major food categories contributing to dietary sodium in the total New Zealand population aged 15 years and older.

(3.8%), and for 'Sausages and processed meats' was Sausages (4.3%) (Appendix Table C1).

3.2. Gender

Fourteen major food categories contributed 80% of dietary sodium for both males and females, of which 12 were the same (Table 1 and Appendix Fig. E1). The top two major sources for both females and males were 'Bread' (18.0% and 18.4%, respectively) and 'Bread-based dishes' (8.2% and 12.8%, respectively). For 'Bread', the top two minor food categories for both females and males were White (7.2% and 7.3%, respectively) and Mixed grain (5.6% for both) varieties, and for 'Bread-based dishes' the top minor category contributor was Sandwiches and filled rolls (for both genders, 4.5% and 6.5%, respectively).

'Grains and pasta', and 'Pork' were also in the top five major food category sources for both genders. The top minor contributors in these major categories were Pasta and sauce and Ham, respectively (for both genders). However, 'Soups and stocks' was a top five major source for females (5.4%) but not males, and 'Sausages and processed meats' (5.4%) was a top five major source for males but not females (Appendix Tables C2 and C3 and Fig. E1).

3.3. Ethnicity

Fourteen major food categories contributed 80% of dietary sodium for Māori, Pacific, and Others, and 11 contributed 80% of dietary sodium for Asian (Appendix B and Fig. E2). The top two major contributors for Māori whānau, Pacific communities, and Others were 'Bread' and 'Bread-based dishes'; the top minor food category contributors of 'Bread' were White and Mixed grain, and the top contributor for 'Bread-based dishes' was Sandwiches and filled rolls (for all groups; Appendix Tables C4, 5 and 7). For Asian, the top major contributors were 'Grains and pasta', and 'Bread'; the top minor contributors under these categories were Fried rice and rice dishes (8.0%) and Noodles (6.3%; Appendix Table C6).

'Grains and pasta' was a top five contributor to dietary sodium for all four ethnic groups, and 'Sausages and processed meats' was in the top five major contributors for three (excluding Asian). Key differences in the major contributors to dietary sodium between ethnic groups were 'Poultry', which was a top five source only for Pacific communities (contributing 5.3%), 'Pork' which was a top five source only for Māori whānau (6.1%) and Others (7%), and 'Vegetables' (9.6%) and 'Soups

and stocks' which were top five sources only for Asian (7.9%) (Appendix Tables C4 to 7, and Fig. E2).

3.4. Age

Thirteen major food categories contributed 80% of dietary sodium for age groups 15 to 20, 21 to 40, and 41 to 60 years, and 11 contributed 80% of dietary sodium for 61+ years (Appendix B and Fig. E3). The top two major sources for the youngest three age groups were 'Bread-based dishes' and 'Bread'; for all age groups the top minor food category contributor of 'Bread-based dishes' was Sandwiches and filled rolls, and the top minor food category contributors of 'Bread' were White and Mixed grain. For those aged 61 years and older 'Bread' was also a top major source (with White and Mixed grain varieties the top minor sources); however, 'Pork' was the other top contributor (providing 6.9% with Ham the top minor source providing 3.9%) (Appendix Tables C8-11 and Fig. E3).

'Grains and pasta', 'Sausages and processed meats', and 'Pork' were the remaining top three major food category contributors to dietary sodium for the three youngest age groups. However, for those aged 61 years and older 'Grains and pasta' was not a top five contributor, but 'Soups and stocks' was, contributing 6.6% (Appendix Table C11 and Fig. E3).

4. Discussion

Our analysis of ANS data identified 14 major food categories contributing the majority (~80%) of dietary sodium for the total NZ population aged 15 years and older. 'Bread' and 'Bread-based dishes' were important contributors to sodium intake for all population groups. However, there were some differences in major food sources of sodium when findings for the total population were compared with those for demographic sub-groups, and when findings within demographic sub-groups were compared.

While our analysis is unique for the 2008/09 NZ ANS dataset, previous work has examined food sources of sodium for adults in the prior (1997) NZ ANS; although food groupings were slightly different, findings were not dissimilar with 12 (compared with 14 in the current analysis) major food categories contributing ~80% of dietary sodium; of those, Bread and Sausages and processed meats were in the top five in both 1997 and 2008/09 (Ministry of Health, 2003). Findings from a 2020 systematic review of dietary sources of salt around the world were

also similar, with Bread and bakery products, Cereals and grains, Meat, and Dairy found to be significant contributors to salt intakes across several countries and continents (Bhat et al., 2020). However, none of this previous research reported food sources of sodium by population subgroup.

The limitations of our analyses include the age of the dataset (2008/09), use of a single dietary recall, and the inability (due to limited data) to assess dietary sodium sources for more genders or specific age and ethnic groups (such as different Pasifika). As such, researchers should be careful in generalising findings and may wish to triangulate the current results with household food purchasing information and/or findings from (future) smaller research studies focussing on specific population groups.

Large and direct impacts on health and healthcare costs have been estimated if NZ adults were supported to achieve the WHO sodium reduction target of <2,000 mg per day (World Health Organization, 2013) i.e. saving 235,000 Quality Adjusted Life Years and \$NZ1260 million in 2011 (Wilson et al., 2016). Nonetheless, NZ does not have a current sodium reduction strategy, and based on the most recent gold standard 24-hour urine analysis in 2013, total population sodium intake far exceeds WHO guidelines (World Health Organization, 2013; Skeaff et al., 2013). Our findings provide information on the major and minor food sources of sodium compared to the total NZ population and specific to important population sub-groups. The differences observed by population subgroup are critical for policymakers to include in the design of an equitable, country-specific programme to reduce population sodium consumption. The development of sodium reduction targets for processed foods included in such a programme must capture the top major sources of dietary sodium for all population subgroups; repeating the total population approach taken in many other countries is unlikely to improve inequities in heart-related health in NZ.

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CRedit authorship contribution statement

Helen C. Eyles: Conceptualization, Methodology, Resources, Writing – original draft, Visualization, Project administration, Funding acquisition. **Christine L. Cleghorn:** Methodology, Validation, Formal analysis, Resources, Data curation, Writing – review & editing, Visualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

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Unpublished ANS data were supplied by Otago University Life in New Zealand staff (personal communication, Blakey, Smith, and Parnell, 2014).

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.pmedr.2022.101927>.

References

- Bhat, S., Marklund, M., Henry, M.E., et al., 2020. A systematic review of the sources of dietary salt around the world. *Adv. Nutr. (Bethesda)* 11, 677–686.
- Ettehad, D., Emdin, C.A., Kiran, A., et al., 2016. Blood pressure lowering for prevention of cardiovascular disease and death: systematic review and meta-analysis. *Lancet* 387, 957–967.
- Grillo, A., Salvi, L., Coruzzi, P., et al., 2019. Sodium intake and hypertension. *Nutrients* 11 (9), 1970.
- F. He J. Li G. MacGregor Effect of longer term modest salt reduction on blood pressure: Cochrane systematic review and meta-analysis of randomised controlled trials *British Medical Journal*. 2013;346(f1325):doi: 10.1136/bmj.f325.
- Hyseni, L., Elliot-Green, A., Lloyd-Williams, F., et al., 2017. Systematic review of dietary salt reduction policies: Evidence for an effectiveness hierarchy? *PLoS ONE* 12 (5), e0177535.
- Ministry of Health, 2003. *NZ Food NZ Children: Key results of the 2002 National Children's Nutrition Survey*. Ministry of Health, Wellington.
- Ministry of Health, University of Auckland. *Nutrition and the Burden of Disease: New Zealand 1997-2011*. Accessed 2/08/18. Available: [http://www.moh.govt.nz/notebook/nbbooks.nsf/0/A8D85BC5BAD17610CC256D970072A0AA/\\$file/nutritionandtheburdenofdisease.pdf](http://www.moh.govt.nz/notebook/nbbooks.nsf/0/A8D85BC5BAD17610CC256D970072A0AA/$file/nutritionandtheburdenofdisease.pdf). Wellington: Ministry of Health; 2003.
- Ministry of Health. *Annual Update of Key Results 2019/20: New Zealand Health Survey*. Accessed 31/05/2021. Available: <https://www.health.govt.nz/publication/annual-update-key-results-2019-20-new-zealand-health-survey>. Wellington: Ministry of Health; 2020.
- Santos, J.A., Tekle, D., Rosewarne, E., et al., 2021. A systematic review of salt reduction initiatives around the world: a midterm evaluation of progress towards the 2025 global non-communicable diseases salt reduction target. *Adv. Nutr. (Bethesda)* 12 (5), 1768–1780.
- Skeaff, M., McLean, R., Mann, J., et al., The impact of mandatory fortification of bread with iodine. Wellington: University of Otago; 2013 August 2013. Contract No.: RFP15169.
- Statistics New Zealand. *Population clock* Wellington: Statistics New Zealand; 2021 [Available from: <https://www.stats.govt.nz/tools/population-clock>].
- Statistics New Zealand. *Population projected to become more ethnically diverse* Wellington: Statistics New Zealand; 2021 [Available from: <https://www.stats.govt.nz/news/population-projected-to-become-more-ethnically-diverse>].
- The University of Otago, Ministry of Health. *A focus on nutrition: Key findings of the 2008/09 New Zealand adult nutrition survey*. Accessed 14/06/2021. Available: <https://www.health.govt.nz/system/files/documents/publications/a-focus-on-nutrition-v2.pdf>. Wellington: Ministry of Health; 2011.
- The University of Otago, Ministry of Health. *Methodology report for the 2008/09 New Zealand Adult Nutrition Survey*. Accessed 14/06/2021 Available: <https://www.health.govt.nz/system/files/documents/publications/methodology-report.pdf>. Wellington: Ministry of Health; 2011.
- Thomson, B., *Survey of salt in processed foods*. Accessed 14/06/2021. Available: <https://www.mpi.govt.nz/dmsdocument/22597/direct>. Christchurch: Institute of Environmental Sciences and Research Ltd; 2006.
- Wilson, N., Nghiem, N., Eyles, H., et al., Modeling health gains and cost savings for ten dietary salt reduction targets. *Nutr. J.*, 2016;15(44): doi: 10.1186/s12937-016-0161-1.
- World Health Organization, 2013. *Global Action Plan for the Prevention and Control of Noncommunicable Diseases 2013–2020*. World Health Organization, Geneva.
- World Health Organization. *Guideline: Sodium intake for adults and children*. Accessed: 18th February 2013. Available: http://www.who.int/nutrition/publications/guidelines/sodium_intake_printversion.pdf. 2012.