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Nutritional modelling: distributions of salt intake from processed foods in New Zealand

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The salt content of processed foods is important because of the high intake of Na by most New Zealanders. A database of Na concentrations in fifty-eight processed foods was compiled from existing and new data and combined with 24 h diet recall data from two national nutrition surveys (5771 respondents) to derive salt intakes for seven population groups. Mean salt intakes from processed foods ranged from 6·9 g/d for young males aged 19–24 years to 3·5 g/d for children aged 5–6 years. A total of ≥50 % of children aged 5–6 years, boys aged 11–14 years and young males aged 19–24 years had salt intakes that exceeded the upper limit for Na, calculated as salt (3·2–5·3 g/d), from processed foods only. Bread accounted for the greatest contribution to salt intake for each population group (35–43 % of total salt intake). Other foods that contributed 2 % or more and common across most age groups were sausage, meat pies, pizza, instant noodles and cheese. The Na concentrations of key foods have changed little over the 16-year period from 1987 to 2003 except for corned beef and whole milk that have decreased by 34 and 50 % respectively. Bread is an obvious target for salt reduction but the implication on iodine intake needs consideration as salt is used as a vehicle for iodine fortification of bread.

Nutritional modelling: Salt: Processed foods: 24 h Diet recall: Intake distribution

Information on the sources and intake of salt in the diet is of interest in a number of countries because of the causative link between high Na (from salt) intake and increased blood pressure leading to CVD, gastric cancer, osteoporosis, cataracts, kidney stones and diabetes[1–3]. Since blood pressure progressively increases above Na exposures of half the adult adequate intake level, and high blood pressure is a risk factor for heart disease that is highly prevalent[4], salt exposure is a public health concern in New Zealand[4].

Salt accounts for approximately 90 % of Na intake with the remainder of Na sourced from food ingredients such as sodium bicarbonate, monosodium glutamate, sodium phosphate, sodium carbonate and sodium benzoate, although these estimates are now dated[5,6]. Dietary salt includes the salt that occurs naturally in most foods, that which is added as an ingredient of processed foods, and that added at the time of cooking or at the table. Processed foods are the major source of salt in our diet contributing between 60 and 80 % of Na, and hence, salt intake[7,8]. Therefore information on the major contributors of salt from processed foods is important for informing salt reduction strategies.

Chemically, salt is sodium chloride comprising Na and Cl ions and therefore salt intake could potentially be derived from either Na or Cl concentrations in foods. In practice, Na content has been cited as the basis for estimates of salt intake[2,9,10] with no reports of Cl intakes found in the literature. In addition, labelling of foods for Na is mandatory in New Zealand and Australia[11], resulting in more information on Na than Cl levels in foods. Therefore the Na concentration of targeted foods was ascertained as the basis for salt content.

Mean daily Na intakes calculated from the 2003–4 New Zealand Total Diet Survey (NZTDS), based on simulated diets and the analysis of 121 widely consumed foods, were two to four times above the adequate intake level for each of the eight age–gender groups considered[12]. This assessment excluded any contribution from salt added at the time of cooking or at the table. Mean Na intakes exceeded the upper intake limits for males aged 25 years and over, young males aged 19–24 years, and 11–14-year-old boys and girls by up to 125 % for the average consumer.

The present study reports consolidated data of Na concentrations in a wider range of New Zealand processed foods than included in the NZTDS, estimates of the distribution and variability of salt intake from consumption of these foods for seven age groups over 5 years of age, based on 24 h diet recall information (n 5771) and trends in the Na content of key foods over the 16-year period 1987–2003.

Materials and methods

Food selection

The selection of fifty-eight processed foods was based on the list of 121 foods included in the 2003–4 NZTDS that represented approximately 70 % of the most commonly consumed foods in New Zealand[3]. Excluded from this list

Abbreviations: CNS, 2002 National Children's Nutrition Survey; NNS, 1997 National Nutrition Survey; NZTDS, New Zealand Total Diet Survey.

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were: non-processed foods (milk, egg, beef-mince, lamb/mutton, beef-rump, pork chop, whole peanuts, carrot, silver-beet, lambs liver, water, potatoes, cream, cabbage, tomato, celery, kumara, apple, oysters, mussels and fresh fish), foods that would be inappropriate to salt (coffee, tea, wine and infant foods), foods where the level of discretionary salt was likely to be highly variable (hot potato chips and takeaways) and foods that made a contribution of $<0{\cdot}05\,\%$ to Na intake. The remaining fifty-one foods were augmented to include processed foods that showed high Na levels in the New Zealand Food Composition Database but were not included in the NZTDS: beef pastrami, frozen beef patties, ham and ham steaks, luncheon meat, sauces and smoked meat and fish (FOODfiles 2004[13]; J McLauglin, personal communication, September 2005).

Concentration of salt in processed foods

Data of Na concentrations in fifty-eight processed foods were collated from the 2003–4 NZTDS[12], the New Zealand Food Composition Database[13] and from the analysis of selected New Zealand manufactured food samples where there was no, or limited, Na concentration data.

Food sampling and analysis

Eight samples of each of the following foods were purchased in October and November 2005 from Christchurch supermarkets except where noted otherwise:

(a) processed chicken, including reformed chicken products (‘Loopys®’ nuggets), hotdogs, stuffed chicken products, crumbed chicken and KFC purchased from Christchurch (four) and Auckland (four) outlets;
(b) bacon, comprising four brands, shoulder and middle;
(c) beef pastrami, comprising five brands of pre-packed and delicatessen products;
(d) convenience foods, including frozen processed potato(cheese medallions, shaped potato pieces, hash brown nuggets), crumbed meats, prepared dinners;
(e) sushi purchased from eight different food stalls located in retail malls;
(f) frozen beef patties, comprising eight pre-packed products representing six brands;
(g) ham and ham steaks, comprising five brands of pre-packed and delicatessen products;
(h) luncheon meat, comprising three brands and six products;
(i) pâté, including eight pre-packed brands;
(j) salami, comprising five brands and seven products;
(k) sauces, mayonnaise dressings, pasta sauces, chilli sauces, stir-fry sauces, piccalilli/chow;
(l) smoked meat/fish, including salmon, mussels, beef and pork representing five brands.

Individual units, or a minimum of 250 g of each sample, were purchased. Details of the label claim were recorded as a cross-reference for the analytical determination of Na.

Samples were analysed as purchased, i.e. raw foods were analysed raw. A minimum of 250 g of each product were homogenised in a domestic blender. Duplicate 50 ml portions were frozen at -18°C until analysis. An aliquot of sample was ashed in a muffle furnace at 500°C, the residue dissolved in concentrated nitric acid Aristar® specific gravity 69%; Merck-BDH, Poole, Dorset, UK), with caesium chloride (Sigma, St Louis, MO, USA) as an ionisation suppressant. Na was determined by atomic emission spectroscopy on a Varian SpectrAA 400 (Varian Australia Pty Ltd, Mulgrave, Victoria, Australia), by the Institute of Environmental Science and Research (ESR) Ltd Christchurch Science Centre food chemistry laboratory that is accredited by International Accreditation New Zealand (IANZ) to the standard NZS/ISO/IEC/17 025, 2.72/5 for this analysis.

Quality assurance of sodium determinations

The following quality assurance procedures were followed to ensure the robustness of the analytical results.

(1) Thirty-two of 168 samples (19 %) were analysed in duplicate, including samples of each food type, to determine variability. The analytical precision and intra-sample variability, expressed as % CV ranged from 0·1 to 10·0 %.
(2) Eleven samples were spiked with Na to correspond to a spike level equivalent to that in the product (i.e. doubling the amount of Na in an extract between the spiked and unspiked samples). Recovery compares the amount of Na measured in the spiked sample corrected for the amount of Na in the unspiked sample, with the amount of Na added in the spike. The recovery of Na from spiked samples ranged from 84 to 102 %, confirming the general accuracy of the analytical method except for the luncheon meat sample. The low recovery for luncheon meat (62 %) is most likely a single poor result. Four duplicate analyses for luncheon meat showed a high degree of reproducibility. A comparison of measured Na levels with the label claim did not show a bias towards a low recovery.
(3) A milk powder certified reference sample (RM155), supplied by AgriQuality (Mt Wellington, Auckland, New Zealand), was analysed with each batch to ensure precision. The analysis of Na in this reference sample ranged from 93 to 130 % of the certified value, also confirming the accuracy of the analytical method.

Assessment of salt intake

Estimates of dietary exposure to salt were made by combining mean Na levels in processed foods with 24 h dietary recall information from the 1997 National Nutrition Survey (NNS)[14] and the 2002 National Children’s Nutrition Survey (CNS)[15] using Microsoft Foxpro (Microsoft Corp., Redmond, WA, USA). Repeat records for a proportion of respondents were used to examine day-to-day variability in individuals’ dietary exposure.

Food descriptors from the NNS and CNS were mapped to the processed foods of interest for the present study. For example, all ‘muesli bars’ in the NNS were mapped to ‘snack bars’. Where a food of interest may be only a component of a described item, such as the bread component of a filled roll, an estimate of the proportion of the food of interest was specified. Each food of interest was assigned a mean Na concentration (as in Table 2). The mean Na concentrations were multiplied by the amount of that food consumed by each respondent in the two consumption surveys, and summed over all foods assessed to estimate the dietary exposure to Na from processed foods for each individual surveyed.

The Na intake was converted to a salt intake by adjusting for the difference in molecular weight (58·5/23·0) and to account for non-salt sources of Na (0·9)[5,8].

Arithmetic mean, selected percentiles, and minimum and maximum exposures were determined using Microsoft Excel (Microsoft Corp.). The distribution of salt intake for each population group was formatted as lognormal graphs with @risk® software (Palisade Corp., Ithaca, NY, USA).

Age–gender population groups evaluated

The two consumption surveys included respondents aged 5–14 years and aged 15 years and over, allowing for exposure estimates for a variety of age and gender groups. The complete sets of dietary exposure estimates were subdivided to provide information on seven subgroupings, namely: males aged 25 years and over, females aged 25 years and over, young males aged 19–24 years, young females aged 19–24 years, boys aged 11–14 years, girls aged 11–14 years and children aged 5–6 years.

Risk characterisation

The adequacy and toxicity of salt intakes were assessed by comparison with Australian and New Zealand reference health standards for Na adopted in 2006[16].

Food contributions

The contribution of a particular food to Na intake was calculated by summing the contributions to Na exposure from each food, across all consumers in a particular age–gender group, and dividing by the sum of all Na exposures for that group. The resulting proportion was converted to a percentage by multiplying by 100.

Trends in sodium content of processed foods

Trends in the Na content of major contributing foods identified from the present study were collated from the three NZTDS where Na was analysed (1987–8[17], 1990–1[18] and 2003–4[12]). Consistent methodologies in terms of sample purchase and preparation provided the best possible data for comparison of concentration change with time.

Results

The mean, minimum and maximum levels of Na in fifty-eight processed foods are shown in Table 1. Seven of the food types had Na concentrations varying by a factor of ten or more, with the greatest range in Na levels seen across the muesli samples. The saltiest food was yeast extract followed by the processed meats (salami, bacon, ham, smoked fish/meat) and flavoured snacks.

Estimates of salt exposure from the consumption of these fifty-eight processed foods, for the seven age–gender groups, are shown in Table 2. Selected percentile consumers, including mean, median, maximum and minimum consumers are presented to illustrate the variability of salt intake. The 5th percentile values were the intake for the lowest 5 % of the population and thus represent very low salt intakes but exclude the extreme values of the minimum consumers. Conversely, the 95th percentile was the intake for the top 95 % of the population, indicative of very high intakes, but excluding the extreme values of the maximum consumers. The zero minimum intake of salt reflects that there were some individuals within each age group who did not consume any of the fifty-eight foods in the 24 h period of the consumption survey. Median salt intakes ranged from 3·1 to 5·5 g/d and maximum salt intakes ranged from 21·5 g/d for a 5–6-year-old child to 51·7 g/d for an adult male aged over 25 years old.

The range of salt intake between the lowest and highest consumers of processed foods (5th and 95th percentiles) varied by a factor of 9 to 32 with the smallest range of intake seen for the younger children, aged 5–6 years, and the widest range observed for the 19–24-year-old females.

For each age–gender group, the median was less than the mean, indicative of right-skewed distributions of intake, illustrated for each subpopulation in Figs. 1 and 2. Also shown are the proportions of each age–gender group that had intakes below the adequate intake level and above the upper limit for Na, from processed foods alone. Between 22 and 52 % of each group had salt intakes that exceeded the upper limit for Na excluding any contribution from discretionary or naturally occurring salt including ≥50 % of 5–6-year-old children, 11–14-year-old boys and 19–24-year-old young males.

Salt was spread across a wide range of foods. For each of the age–gender groups, bread, white and wheatmeal combined, clearly made the greatest contribution accounting for 35–43 % of salt intake. Other foods that contributed 2 % or more to salt intake and were common across the age groups were sausage, meat pies, pizza, instant noodles (except for the males aged 25 years or over) and cheese (except for the 5–6-year-old children) (Fig. 3). Biscuits, potato crisps and tomato sauce were salt-contributing foods common for young people (aged 5–11 years).

Processed foods that contributed more than 2 % of the salt intake and were specific to particular age–gender groups were:

(1) 25 + -year-old males: bacon (2·9 %), margarine (2·6 %), corned beef (2·5 %), ham (2·3 %) and butter (2·1 %).
(2) 25 + -year-old females: cake (2·6 %), margarine (2·6 %), muffin (2·5 %), bacon (2·4 %), soup (2·1 %), butter (2·1 %), corned beef (2·0 %) and yeast extract (2 %).
(3) Young males: hamburgers (6·2 %), tomato sauce (3·2 %) and pasta sauce (2·4 %).
(4) Young females: bacon (2·2 %), tomato sauce (2·2 %), corned beef (2·1 %), soup (2·0 %), margarine (2·0 %) and flavoured snacks (2·0 %).
(5) 11–14-year-old boys: ham (4·0 %), biscuits (2·6 %), tomato sauce (2·5 %), flavoured snacks (2·5 %), corned beef (2·4 %) and potato crisps (2·0 %).
(6) 11–14-year-old girls: flavoured snacks (3·4 %), biscuits (3·0 %), ham (2·7 %), potato crisps (2·4 %), corned beef (2·4 %) and tomato sauce (2·3 %).
(7) 5–6-year-old children: plain biscuits (3·1 %), flavoured snacks (3·1 %), ham (2·7 %), canned spaghetti (2·6 %), potato chips (2·0 %) and tomato sauce (2·0 %).

The mean concentrations of Na in those foods making the greatest contribution to salt intake from processed foods,

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Table 1. Consolidated data of sodium in New Zealand processed foods

Food	Samples (*n*)	Mean (mg/kg)	Minimum (mg/kg)	Maximum (mg/kg)
Bacon*†	16	13 081	4950	18 900
Baked beans, canned†‡	9	4201	3190	5150
Beef patty*	8	3800	1000	5760
Beetroot, canned†‡	9	1770	349	3430
Biscuit, chocolate†‡	16	1808	610	3030
Biscuit, cracker†‡	19	5787	2410	8850
Biscuit, plain sweet†‡	28	2979	1130	6870
Bran flake cereal, mixed†‡	14	3409	50	9590
Bread, mixed grain†‡	30	4406	3630	6660
Bread, wheatmeal†‡	21	5317	4520	7460
Bread, white†‡	24	5015	3300	8330
Butter†‡	10	5430	4800	5960
Cake†‡	31	2600	740	4040
Cheese†‡	25	6796	2400	16 900
Corn, canned†‡	9	1375	953	2470
Corned beef†‡	12	8353	6200	11 300
Cornflakes†‡	10	7495	4460	9820
Crumbed chicken*	8	3133	2020	4290
Crumbed meat*	8	4120	3050	5570
Dairy dessert†	8	569	493	723
Fish fingers†‡	18	5082	2760	10 000
Ham*†‡	17	12 788	9430	15 000
Hamburger†‡	16	4602	3490	6870
Ice-cream†‡	20	475	320	720
KFC chicken*	8	6301	4340	8030
Luncheon meat*‡	10	10 270	7450	12 530
Margarine†‡	12	5368	2500	7760
Meat pie†‡	15	4275	2580	5320
Milk, flavoured†‡	15	494	334	730
Muesli†‡	14	1600	50	4820
Muffin†‡	12	4033	2200	7300
Noodles, instant†‡	13	2922	880	5600
Pastrami*	8	11 604	9130	14 370
Pâté*‡	11	7573	3340	14 370
Peanut butter†‡	9	4131	1590	6100
Piccalilli*‡	10	5511	2080	17 000
Pizza†	8	5914	5250	7240
Potato crisps†‡	15	4507	880	7600
Prepared meal*	8	3449	2160	5300
Processed chicken*	8	6363	4020	8030
Processed potato*	8	3065	1740	3660
Salad dressing, mayonnaise*†‡	9†	7685	2190	12 600
Salami*	8	15 136	7310	20 220
Sauce, chilli or stir-fry*	16	9567	2140	21 550
Sauce, pasta*	8	4701	3570	7670
Sausage*†	12	8520	6130	11 900
Smoked fish/meat*†	12	10 870	4050	17 300
Snack bar†‡	27	1205	220	3550
Snacks, flavoured†‡	13	10 035	5130	21 300
Soup†‡	28	2779	940	4990
Spaghetti, canned†‡	9	4177	3320	4790
Stuffed chicken*	8	4640	2210	8500
Sushi*‡	9	4336	2430	7010
Tomato, canned†‡	9	1194	49	2670
Tomato sauce†‡	10	7423	4760	11 500
Wheatbix†‡	9	2730	50	3920
Yeast extract†‡	7	38 229	32 300	44 000
Yoghurt†‡	14	397	60	512

* Results from the present study.
† Data from the 2003–4 New Zealand Total Diet Survey[12].
‡ Data from FOODfiles 2004[13].

across the time period of 1987 to 2003, are shown in Table 3. With the exception of corned beef and whole milk that have decreased by 34 and 50 % respectively, there has been little change in Na concentration of these foods over the 16-year period.

Discussion

Whilst analysis of 24 h urinary samples is considered the most accurate method of assessing Na[1,3,19,20], and hence salt intake, such studies are difficult to undertake for large

Table 2. Dietary intake estimates of salt (g/d) from fifty-eight processed foods for seven subpopulations and adequate intakes(AI) and upper limits (UL)

	25+ years male	25+ years female	19–24 years male	19–24 years female	11–14 years boy	11–14 years girl	5–6 years child
*n**	1648	2309	141	205	567	576	692
Mean	5·9	3·9	7·0	5·2	5·3	4·2	3·5
Median	4·6	3·1	5·5	3·7	4·6	3·8	3·3
Minimum	0	0	0	0	0	0	0
5th Percentile	0·9	0·4	0·5	0·4	1·1	0·7	0·9
95th Percentile	14·0	9·6	14·7	12·7	12·0	9·6	7·8
Maximum	51·7	49·3	31·7	30·1	31·8	40·6	21·5
AI†	1·0–2·1	1·0–2·1	1·0–2·1	1·0–2·1	0·9–1·8	0·9–1·8	0·7–1·4
UL‡	5·3	5·3	5·3	5·3	4·6	4·6	3·2

* Number of respondents in 24 h diet recall survey.
† AI for Na[16] converted to salt intake (Na value × 58·5/23·0 × 0·9).
‡ UL for Na[16] converted to salt intake (Na value × 58·5/23·0 × 0·9).

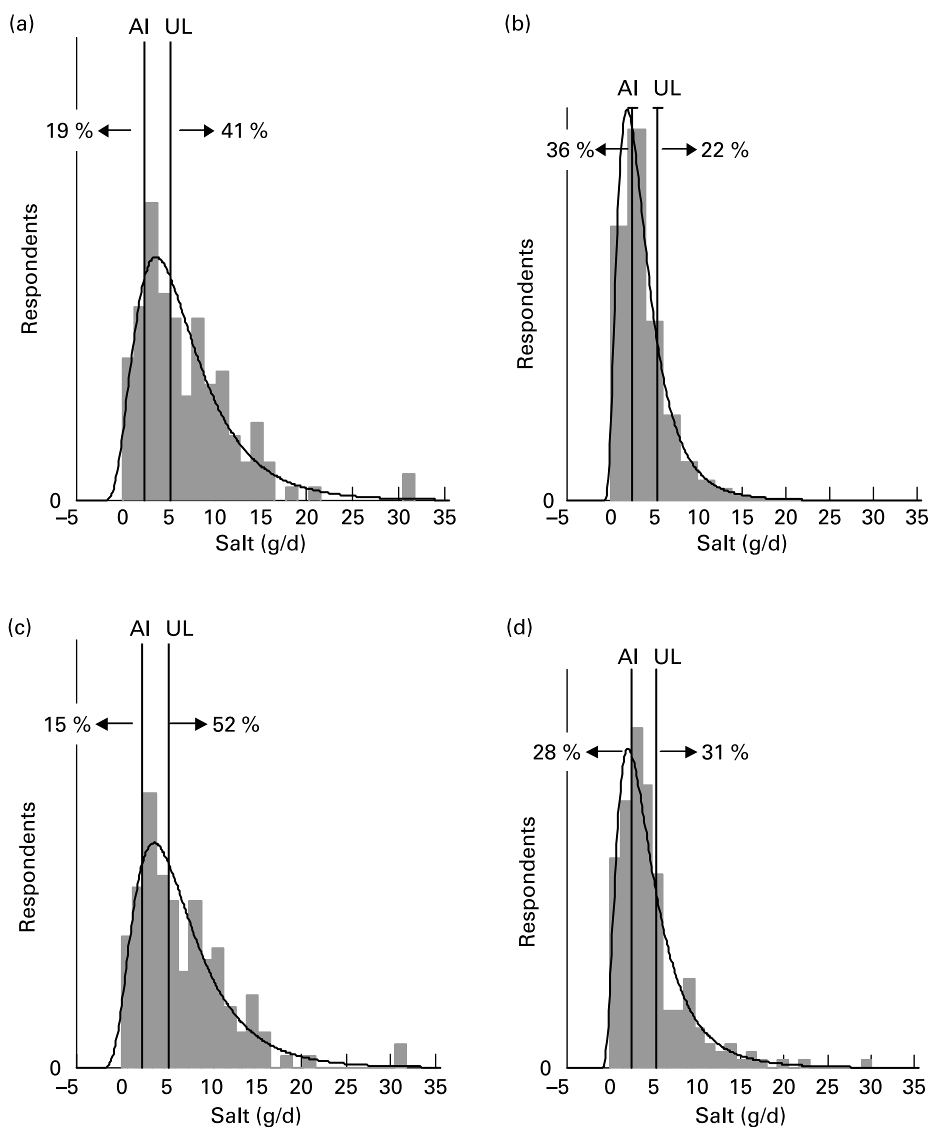

Fig. 1. Distribution of salt intake from processed foods (g/d) for males 25+ years (a), females 25+ years (b), young males 19–24 years (c) and young females 19–24 years (d) showing the proportions of the population groups below and above adequate (adequate intake; AI) and upper (upper limit; UL) Na reference intake values.

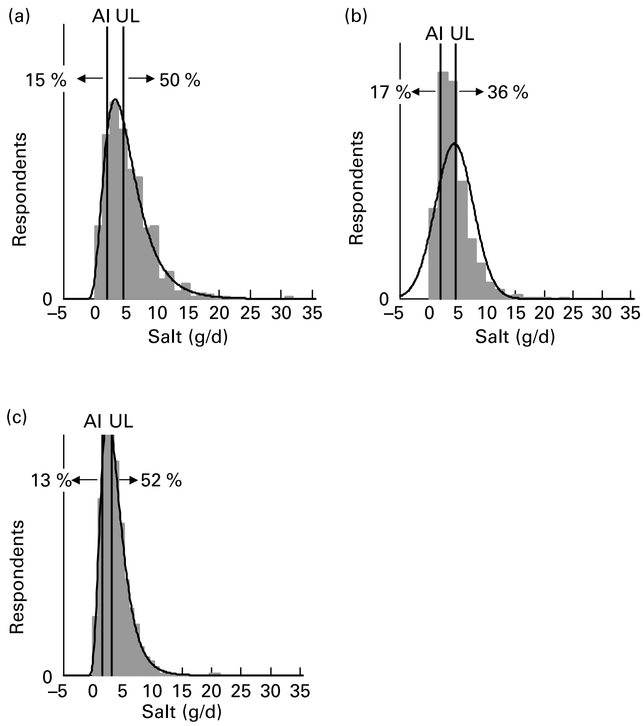

Fig. 2. Distribution of salt intake from processed foods (g/d) for boys 11–14 years (a), girls 11–14 years (b) and children 5–6 years (c) showing the proportions of the population groups below and above adequate (adequate intake; AI) and upper (upper level; UL) Na reference intake values.

populations and do not provide information on the relative contributions of different foods to salt intake; thus the need for dietary surveys. Calculating Na intake from dietary recalls and diaries has been validated against 24 h urinary analysis and is considered a valid approach, provided that food concentration data are of good quality[20]. Dietary surveys do, however, have the limitation of not being able to accurately assess the contribution from salt used in cooking and at the table. In addition, neither 24 h urinary samples nor 24 h diet recall surveys allow for day-to-day variations in salt intake[21,22]. Such variability is more accurately covered by 7 d or 3 d dietary records, but these are not available for New Zealand consumers. The day-to-day variability was recognised, and assessed, by calculating salt intakes from the 15–20 % of individuals who completed a second questionnaire for a subsequent 24 h period. A comparison between the main and repeat data for the NNS and CNS showed agreement within 15 % at the 95th percentile of consumers for each age–gender group, apart from the 5–6-year-olds (21 % difference between the datasets), and were therefore considered fair assessments of habitual intake for these age–gender groups. The estimates of the 5–6-year-olds would tend to less accurately reflect habitual exposure than for the older consumers because of the slightly poorer agreement between estimates based on main and repeat data.

A further limitation of the methodology relates to the targeted processed foods. Not all salt-containing processed foods were included in the assessment. Whilst every effort was made to include the likely major contributors, it was not practical to include the complete array of foods that is available and therefore intakes will be underestimated for some consumers. The fifty-eight foods included in the study were mapped to a wider range of foods described in the NNS/CNS requiring assumptions that mapped foods have similar Na concentrations to the analysed foods. There is a measure of uncertainty around these assumptions.

Salt intake from processed food increased with age and was higher for males than females, consistent with Na intakes from the NZTDS[12] and international studies[19–21]. The estimation that over 50 % of young children aged 5–6 years exceeded the upper intake limits for Na, based on processed foods only, is clearly an area for concern and a target area for risk

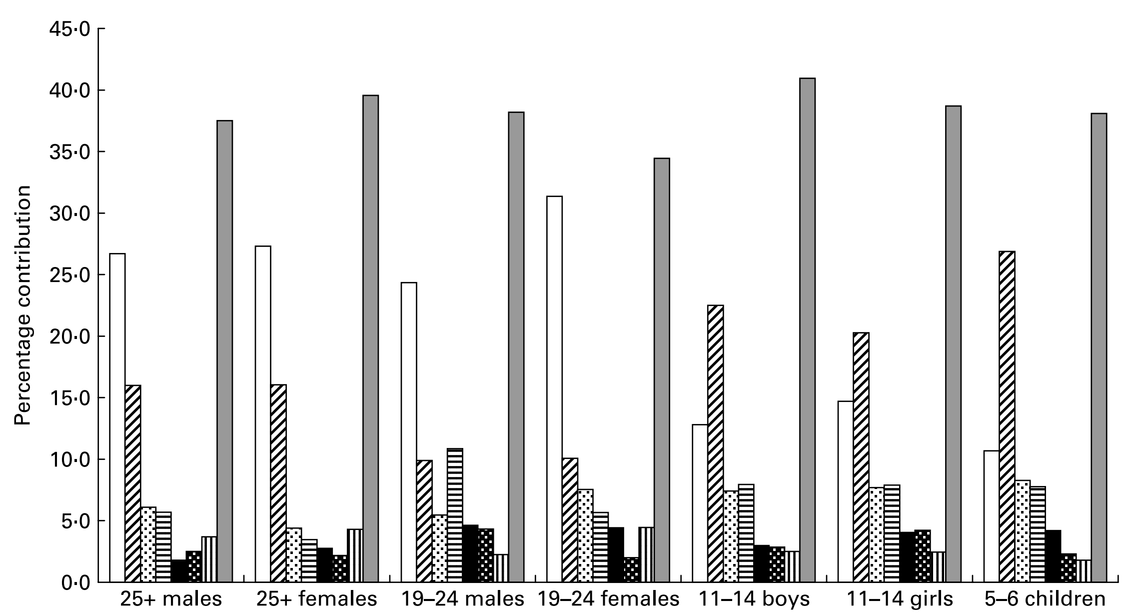

Fig. 3. Foods contributing more than 2 % of salt intake from fifty-eight processed foods that were common across the seven population groups. (□), White bread; (▨), wheatbread; (⊡), sausage; (▤), meat pie; (■), instant noodles; (▩), pizza; (▥), cheese; (▦), other.

Table 3. Mean sodium concentration (mg/kg) of targeted processed foods as reported in successive New Zealand Total Diet Surveys, Australian and United States Department of Agriculture food composition tables

	New Zealand			Australia		USA		
Food	1987–8[17]	1990–1[18]	2003–4[12]	1982*	2007[27]	1982–91[28]	2001†	2008[29]
Bacon	16 860	13 392	15 250	16 000	17 680	15 100	16 057	14 878
Biscuit, plain sweet	3720	4128	3620	3600	2900	NA	NA	5800
Bread, white	5815	5960	5063	4900	4490	5310	5481	6903
Bread, wheat	5390	5469	5006	4400	4300	5270	4977	5251
Butter	4830	2923	5586	720	6100	5680	5618	5775
Cheese	6880	6513	6304	6500	6540	6060	6461	6208
Corned beef	13 220	8666	8704	10 902	11 690	NA	NA	10 070
Ham	NA	NA	13 275	13 501	14 710	12 800	10 988	12 306
Hamburger	NA	NA	3074	5636	6600	3820	3516	3909
Meat pie	4462	3733	4599	6000	4620	NA	NA	NA
Milk, 3·25 %	760	520	383	510	360	420	403	437
Pizza	NA	NA	5914	6700	5170	5540	5555	5010
Potato crisps	4380	5719	3728	9300	6840	NA	NA	NA
Sausages	7635	7085	7352	8600	7030	9110	7836	7673
Tomato sauce	6330	7323	7073	9700	9380	5200	5303	NA

NA, not available.
* Data from R Wills, University of Newcastle, Australia, personal communication, 2007.
† Data from K Egan, US Food and Drug Administration Total Diet Study, personal communication, 2005.

communicators, parents and the food industry. Whilst the evidence for a causal relationship between salt (sodium chloride) and blood pressure in adults is internationally accepted[3] it is less clear for children. He & MacGregor reported small increases in blood pressure with increases in salt intake from a meta-analysis of salt reduction trials[23] and a large cross-sectional study of British children and adolescents aged between 4 and 18 years[19]. In addition to any elevated blood pressure in early life being tracked into adulthood[19], these children will plausibly be developing a preference for a salty diet that will potentially predispose them to high blood pressure as adults since they will probably continue to eat salty foods.

The intake distribution curves (Figs. 1 and 2) show that a proportion of each age–gender group consumed less salt than recommended, with 36 % of female adults over 25 years of age being in this category. It is hoped that these people use some salt in cooking or at the table, otherwise they are at risk of an insufficient intake. In the drive to reduce salt intake[3], public health messages need to be clear that some salt is necessary for good health.

Clearly, a significant proportion of the New Zealand population consumes excessive amounts of salt from processed foods. For salt reduction strategies, bread is a logical target with evidence that the salt level in bread may be reduced by up to 25 % without a noticeable difference in taste[24]. Also of note is that breads at the lower end of the price range contain more Na than more expensive products[25], disadvantaging the cost-conscious consumer. A partnership between the New Zealand Heart Foundation and the two major bread manufacturers is currently underway to reduce the content of Na in low-cost high-volume bread to 4500 mg/kg. This initiative is predicted to remove up to 150 tonnes salt/year from the bread supply[26].

Unlike Finland where Na intake has decreased by about 15 % in men and about 17 % in women between 1992 and 2002, Na (and hence salt) intake in New Zealand has been relatively constant over the 16-year period from 1987 to 2003[12]. Since intake is the product of concentration and consumption, it is of interest to track the concentration of salt in processed foods over time. One of the strengths of the NZTDS studies is the consistency of methodologies applied, especially in the selection of samples for analysis and the rigour of the chemical analyses. Each NZTDS reflects those brands most commonly consumed at the time of the study. Given the international recommendation to reduce average adult salt consumption to <5 g/d[3], there is a surprising lack of readily available longitudinal data on the concentration of salt (or Na) in foods that are the major contributors to salt intake. The consistency of Na concentrations in New Zealand bacon, ham and cheddar cheese is also observed in data from Australia (R Wills, University of Newcastle, Australia, personal communication, 2007; Food Standards Australia New Zealand[27]) and the USA (Pennington *et al.* [28]; United States Department of Agriculture[29]; K Egan, US Food and Drug Administration Total Diet Study, personal communication, 2005). The mean concentration of Na in New Zealand bread appears to have dropped between 1990–1 and 2003–4, mirrored by smaller decreases in Australia, but not in the USA. The decrease in New Zealand milk is also observed in data from Australia, but not for the USA. With the international interest in reducing salt intakes and the proliferation of low-sale variants of many foods, it is perhaps surprising that there has not been a more apparent drop in mean concentration values of key foods.

Messages promoting the consumption of less processed food and reduced levels of salt in processed foods, particularly bread, are identified strategies towards reducing the risk of heart disease. However, a reduction in the amount of salt in bread will have implications on iodine intake. In contrast to high salt intakes, most New Zealanders have iodine intakes well below those recommended for optimal health[12]. In order to redress the mild to moderate iodine deficiency in

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New Zealand[30], the food regulatory authority (Food Standards Australia and New Zealand (FSANZ)) has mandated the use of iodised salt in the manufacture of bread, from October 2009[31]. The level of fortification of iodine in salt may require re-evaluation if the level of salt in bread drops. The need for a careful balance between Na and iodine intakes will require ongoing monitoring to ensure that risk management strategies, for factors such as mental development, are working.

The implication of the range and uneven distribution of salt intakes presented in the present study is that in the event of iodised salt being voluntarily or mandatorily used in the manufacture of processed foods, the intake of iodine will potentially vary by factors of up to 9–32 for different population groups, and the distribution of iodine intake will be influenced by the intake distribution observed for salt intakes.

The potential conflict between the two major health goals of reducing average population salt intake and eliminating iodine deficiency is recognised internationally. Despite this potential conflict, the iodisation of salt was recently reaffirmed as an appropriate strategy to control iodine deficiency[32].

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