Identification of foods to monitor the sodium content of processed foods for developing a sodium reduction program in the Philippines

Maria Sofia Amarra (amarra.sofia@gmail.com)
University of the Philippines Diliman https://orcid.org/0000-0002-4601-0939
Mario Capanzana
Food and Nutrition Research Institute (retired)
Glen Gironella
Food and Nutrition Research Institute
Francisco de los Reyes
University of the Philippines Diliman

Research

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Abstract

Background

In response to the global target for reduction in salt intake, several countries have implemented population sodium reduction strategies. These strategies include identification of major sources of sodium in the diet and reformulation of a set number of products available on the market. This study aimed to identify processed foods that can be targeted for reformulation and whose sodium content can be monitored over time in order to reduce sodium intake in the Philippines. The objectives were to: 1) Estimate per capita sodium intake from minimally processed and processed food groups by income quintile and urban/rural location; 2) Identify foods that contribute to the variance in per capita sodium intake that can be used as indicators for monitoring the sodium content of Philippine processed foods. One-day household food weighing data covering 4880 households from the 2008 National Nutrition Survey was used. Per capita sodium consumption from processed and minimally processed food categories and percentiles of sodium intake from these categories by income quintile and urban/rural location were obtained. The percentage contribution of different food categories to mean per capita sodium intake was calculated. Specific foods that contributed to the variance in sodium intake among Filipinos were identified.

Results

Foods which significantly accounted for 99.4% of the variance in sodium intake were 13 types of processed foods and 2 types of minimally processed foods. The category Processed Soup, Sauces, and Flavor Enhancers contributed the greatest proportion to per capita sodium intake. Specific processed foods that contributed to the variance in per capita sodium intake were instant noodles, traditional fermented condiments and sauces, dried and processed meat, fish, and poultry products, salted eggs, white bread and *pan de sal* (a traditional Filipino bread), wheat and egg noodles, crispy cereal chips and extruded snacks, butter and margarine, cheese, and chocolate-based beverages.

Conclusion

Identifying processed foods that significantly contribute to sodium intake, followed by reformulating and monitoring the sodium content of these foods over time should be considered as one strategy to reduce sodium intake in the Philippines.

Background

Hypertension is a risk factor for cardiovascular disease driven by excess dietary salt intake. The WHO Global Action Plan for the Prevention and Control of Noncommunicable Diseases 2013–2020 [1] set voluntary targets for achievement in 2025 by its Member States, including “a 30% relative reduction in mean population intake of salt/sodium (Na)” towards the recommended level of 2000 mg Na/day (5 g salt/day). This can be achieved by developing “guidelines, recommendations or policy measures that engage different relevant sectors, such as food producers and processors, and other relevant commercial operators, as well as consumers, to reduce the level of salt/sodium added to food (prepared or processed) [1].” In response to the global target for reduction in salt intake, several countries have implemented population sodium reduction strategies. These strategies include identification of major sources of sodium in the diet and reformulation of a set number of products available on the market [2]. In the United States, a sodium monitoring program led by USDA tracks “sentinel foods” i.e., foods that contribute to sodium intake in the population and are used as indicators to track changes in the sodium content of processed foods [3]. Since most sodium in the diet comes from processed foods, reducing the amount of sodium in sentinel foods will translate into reduced sodium intake at the population level. The present study aimed to identify processed foods that can be targeted for reformulation to reduce sodium intake among Filipinos, using one-day household food weighing data from the 2008 National Nutrition Survey. The objectives were to: 1) Estimate per capita sodium intake from minimally processed and processed food groups by income quintile and urban/rural location; 2) Identify foods that significantly contribute to the variance in per capita sodium intake among Filipinos which can potentially serve as indicator foods to monitor the sodium content of processed foods.

Results

a. Per capita sodium intake from different food categories

Table 1 shows the mean per capita sodium intake and percentile distribution of sodium intake from minimally processed and processed food groups. Mean per capita intake exceeded the WHO recommendation of 2000 mg sodium, with rural households ingesting more sodium than urban households. Median sodium intake was highest for Processed Soup, Sauces & Flavor Enhancers, with half of the population consuming > 1416 mg Na from this food category alone. Median intake was highest among the highest income households.

Table 1
Mean per capita intake by urban/rural location and percentile distribution of sodium (mg/day) ingested from minimally processed and processed food groups by income quintile and urban/rural location

	Per capita Na intake (mg/day)														
	Urban					Rural					Both				
Mean ± SE	2767 ± 57					2862 ± 68					2813 ± 44				
Minimally processed foods	P25	P50	P75	P99	IQR	P25	P50	P75	P99	IQR	P25	P50	P75	P99	IQR
A. Fish, meat, poultry															
- Q1 (lowest)	3	24	62	547	59	0	18	56	693	56	0	18	56	675	56
- Q2	24	49	105	597	81	10	43	93	730	83	17	45	95	713	79
- Q3	34	64	124	776	89	25	58	118	585	94	30	61	121	756	91
- Q4	42	80	141	637	99	44	95	173	953	129	43	87	150	784	107
- Q5 (highest)	63	107	175	869	112	67	110	189	1173	123	64	108	176	880	112
- All wealth quintiles	38	77	139	756	101	10	48	105	846	95	24	62	125	776	101
B. Rice, cereals, starches															
- Q1	50	76	101	240	51	53	87	114	244	61	53	86	112	244	60
- Q2	60	76	104	192	44	62	85	115	244	53	62	81	110	207	48
- Q3	60	78	101	194	41	62	82	110	190	47	61	80	106	193	45
- Q4	58	74	95	187	37	61	81	113	319	52	58	76	100	219	42
- Q5	51	68	88	170	38	51	78	100	279	49	51	69	92	205	41
- All	56	73	96	193	40	59	84	112	239	53	57	78	104	213	47
C. Vegetables & fruits															
- Q1	2	4	15	90	13	2	8	17	128	16	2	7	17	105	15
- Q2	1	5	13	131	11	2	8	19	82	17	2	7	16	119	15
- Q3	3	7	15	72	12	3	7	16	125	13	3	7	15	91	12
- Q4	3	9	17	85	13	4	10	21	112	17	3	9	18	94	15
- Q5	4	10	20	104	15	4	10	21	120	16	4	10	20	104	16
- All	3	8	16	90	13	3	8	18	125	16	3	8	17	104	14
D. Milk															
- Q1	0	0	0	48	0	0	0	0	55	0	0	0	0	55	0
- Q2	0	0	1	69	1	0	0	0	81	0	0	0	0	78	0
- Q3	0	0	8	90	8	0	0	2	76	2	0	0	6	79	6
- Q4	0	0	8	138	8	0	0	14	77	14	0	0	9	106	9
- Q5	0	0	12	134	12	0	0	9	101	9	0	0	12	131	12
- All	0	0	8	118	8	0	0	0	73	0	0	0	5	90	5

	Per capita Na intake (mg/day)														
	Urban					Rural					Both				
E. Beans, nuts, seeds															
- Q1	0	0	0	9	0	0	0	0	7	0	0	0	0	7	0
- Q2	0	0	0	8	0	0	0	0	8	0	0	0	0	8	0
- Q3	0	0	0	7	0	0	0	0	10	0	0	0	0	9	0
- Q4	0	0	0	7	0	0	0	0	16	0	0	0	0	10	0
- Q5	0	0	0	6	0	0	0	0	4	0	0	0	0	6	0
- All	0	0	0	7	0	0	0	0	9	0	0	0	0	8	0
	Urban					Rural					Both				
Processed foods	P25	P50	P75	P99	IQR	P25	P50	P75	P99	IQR	P25	P50	P75	P99	IQR
A. Processed soups, sauces & flavor enhancers															
- Q1	499	1118	2122	8113	1623	740	1446	2483	9307	1743	691	1413	2459	8776	1767
- Q2	354	1082	1988	7526	1634	718	1474	2689	7452	1970	555	1354	2484	7452	1929
- Q3	333	1137	2174	7035	1841	833	1498	2547	8174	1715	510	1331	2372	8000	1862
- Q4	569	1375	2574	10021	2004	926	1679	2775	7908	1849	666	1454	2707	9693	2041
- Q5	705	1537	2943	8020	2238	916	1812	3114	10778	2198	713	1630	2959	8720	2246
- All	508	1309	2496	8301	1988	770	1524	2635	8600	1866	629	1416	2556	8315	1926
B. Processed fish, meat & poultry products															
- Q1	0	84	209	1370	209	0	57	281	1762	281	0	61	268	1641	268
- Q2	0	95	320	1501	320	0	128	341	1596	341	0	113	332	1596	332
- Q3	0	131	362	1562	362	0	140	353	1775	353	0	132	360	1721	360
- Q4	0	139	424	2474	424	0	128	429	2408	429	0	135	429	2474	429
- Q5	0	152	456	1957	456	0	143	349	1553	349	0	150	431	1888	431
- All	0	131	392	1900	392	0	110	330	1762	330	0	120	358	1829	358
C. Baked products															
- Q1	0	0	55	289	55	0	0	10	353	10	0	0	14	353	14
- Q2	0	25	145	695	145	0	0	49	396	49	0	0	86	531	86
- Q3	0	67	187	655	187	0	8	91	748	91	0	36	144	679	144
- Q4	0	86	240	792	240	0	32	142	550	142	0	63	207	771	207
- Q5	30	142	317	920	287	0	87	275	1088	275	23	131	305	934	282
- All	0	77	228	771	228	0	0	72	582	72	0	25	150	720	150

	Per capita Na intake (mg/day)														
	Urban					Rural					Both				
D. Instant noodles															
- Q1	0	0	0	1076	0	0	0	0	1050	0	0	0	0	1064	0
- Q2	0	0	0	1067	0	0	0	11	1044	11	0	0	0	1067	0
- Q3	0	0	0	1163	0	0	0	0	960	0	0	0	0	1032	0
- Q4	0	0	0	922	0	0	0	0	800	0	0	0	0	907	0
- Q5	0	0	0	990	0	0	0	0	1110	0	0	0	0	1000	0
- All	0	0	0	1050	0	0	0	0	1009	0	0	0	0	1032	0
E. Other noodles & pasta															
- Q1	0	0	0	180	0	0	0	0	310	0	0	0	0	259	0
- Q2	0	0	0	296	0	0	0	0	360	0	0	0	0	360	0
- Q3	0	0	1	445	1	0	0	0	388	0	0	0	1	445	1
- Q4	0	0	1	349	1	0	0	0	502	0	0	0	1	423	1
- Q5	0	0	2	604	2	0	0	1	745	1	0	0	1	604	1
- All	0	0	1	482	1	0	0	0	423	0	0	0	0	450	0
F. Rice, cereal, starch products															
- Q1	0	0	0	140	0	0	0	0	143	0	0	0	0	142	0
- Q2	0	0	0	221	0	0	0	0	213	0	0	0	0	221	0
- Q3	0	0	1	221	1	0	0	0	156	0	0	0	0	178	0
- Q4	0	0	4	289	4	0	0	1	238	1	0	0	3	238	3
- Q5	0	0	20	228	20	0	0	17	461	17	0	0	19	276	19
- All	0	0	6	235	6	0	0	0	209	0	0	0	1	221	1
G. Non-alcoholic beverages															
- Q1	0	0	4	44	4	0	0	3	67	3	0	0	3	67	3
- Q2	0	0	11	81	11	0	0	7	89	7	0	0	9	82	9
- Q3	0	2	16	104	16	0	1	13	71	13	0	1	14	84	14
- Q4	0	4	20	119	20	0	3	23	106	23	0	3	21	106	21
- Q5	0	10	29	152	28	0	8	22	232	22	0	9	27	159	27
- All	0	3	19	115	19	0	0	10	91	10	0	1	15	105	15
H. Milk formula & milk products															
- Q1	0	0	0	5	0	0	0	0	9	0	0	0	0	9	0
- Q2	0	0	0	99	0	0	0	0	40	0	0	0	0	55	0
- Q3	0	0	0	142	0	0	0	0	67	0	0	0	0	120	0

	Per capita Na intake (mg/day)														
	Urban					Rural					Both				
- Q4	0	0	0	246	0	0	0	0	262	0	0	0	0	246	0
- Q5	0	0	31	362	31	0	0	12	297	12	0	0	26	362	26
- All	0	0	0	285	0	0	0	0	91	0	0	0	0	215	0
I. Fats, oils, & products															
- Q1	0	0	1	20	1	0	0	0	24	0	0	0	1	23	1
- Q2	0	0	2	41	2	0	0	1	34	1	0	0	2	41	2
- Q3	0	0	3	155	3	0	0	2	95	2	0	0	3	98	3
- Q4	0	1	5	89	5	0	0	3	196	3	0	0	4	117	4
- Q5	0	2	6	176	6	0	0	5	208	4	0	1	5	176	5
- All	0	0	3	131	3	0	0	2	82	2	0	0	3	106	3
J. Beans, nuts, seed products															
- Q1	0	0	0	5	0	0	0	0	1	0	0	0	0	3	0
- Q2	0	0	0	11	0	0	0	0	9	0	0	0	0	11	0
- Q3	0	0	0	24	0	0	0	0	3	0	0	0	0	21	0
- Q4	0	0	0	28	0	0	0	0	13	0	0	0	0	24	0
- Q5	0	0	0	28	0	0	0	0	45	0	0	0	0	28	0
- All	0	0	0	24	0	0	0	0	8	0	0	0	0	14	0
K. Sugars & sweets															
- Q1	0	0	2	40	2	0	0	2	21	2	0	0	2	21	2
- Q2	0	0	1	12	1	0	1	3	26	3	0	0	2	19	2
- Q3	0	0	1	19	1	0	0	2	23	2	0	0	2	20	2
- Q4	0	0	1	39	1	0	0	2	33	2	0	0	2	33	2
- Q5	0	0	2	43	2	0	0	2	57	2	0	0	2	43	2
- All	0	0	1	29	1	0	0	2	23	2	0	0	2	26	2
L. Vegetable & fruit products															
- Q1	0	0	0	134	0	0	0	0	0	0	0	0	0	0	0
- Q2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
- Q3	0	0	0	11	0	0	0	0	5	0	0	0	0	6	0
- Q4	0	0	0	16	0	0	0	0	11	0	0	0	0	16	0
- Q5	0	0	0	50	0	0	0	0	5	0	0	0	0	49	0
- All	0	0	0	30	0	0	0	0	4	0	0	0	0	15	0
M. Alcoholic beverages															
- Q1	0	0	0	0	0	0	0	0	3	0	0	0	0	1	0

	Per capita Na intake (mg/day)														
	Urban					Rural					Both				
- Q2	0	0	0	4	0	0	0	0	25	0	0	0	0	15	0
- Q3	0	0	0	2	0	0	0	0	2	0	0	0	0	2	0
- Q4	0	0	0	1	0	0	0	0	20	0	0	0	0	4	0
- Q5	0	0	0	5	0	0	0	0	109	0	0	0	0	5	0
- All	0	0	0	3	0	0	0	0	6	0	0	0	0	4	0

b. Percentage contribution of processed and minimally processed foods to per capita sodium intake

Table 2 shows the percentage contribution of processed and minimally processed foods to per capita sodium intake of urban and rural households across income quintiles.

Processed foods. In both urban and rural households, Processed Soup, Sauces and Flavor Enhancers contributed the greatest amount (> 50%) to sodium intake, followed by Fish, Meat and Poultry Products. Rural households consumed more Processed Soup, Sauces and Flavor enhancers across all income quintiles than urban households. Baked Products and Instant Noodles were the next highest contributors. Urban households consumed more Baked Products while rural households consumed more Instant Noodles.

Minimally processed foods. Among the highest income quintiles, minimally processed food categories that contributed the most sodium were Fish, Meat and Poultry followed by Rice, Cereals and Starches. In lower income quintiles, (Q1 in urban and rural areas, and Q2 in rural areas), Rice, Cereals and Starches contributed the most sodium followed by Fish, Meat and Poultry. In both urban and rural locations, Vegetables and Fruits contributed minimal amounts (< 1%) of sodium. Foods that contributed the least amount to sodium intake were Milk followed by Beans, Nuts and Seeds.

Table 2. Percentage contribution of processed and minimally processed foods to per capita sodium intake by income quintile in urban and rural households. Philippines 2008.

	Percentage contribution to mean per capita Na intake (%)											
	Urban households						Rural households					
	Q1	Q2	Q3	Q4	Q5	All	Q1	Q2	Q3	Q4	Q5	All
1. Processed foods												
Processed soup, sauces & flavor enhancers	57.96	55.86	58.14	73.20	76.56	67.36	71.62	72.7	74.93	79.39	97.41	75.83
Processed fish, meat & poultry products	7.37	8.77	9.96	11.53	12.34	10.75	7.41	9.10	9.70	11.29	9.90	9.08
Baked products	1.55	3.85	4.82	5.85	7.83	5.66	1.01	1.71	2.80	3.75	6.48	2.40
Instant noodles	3.33	3.93	3.87	3.21	3.04	3.45	3.94	4.37	3.82	3.52	3.09	3.89
Other noodles & pasta	0.46	0.68	1.02	0.93	1.07	0.92	0.47	0.51	0.70	0.99	1.37	0.68
Rice, cereal, starch products	0.38	0.50	0.56	0.80	0.83	0.68	0.26	0.52	0.46	0.54	0.96	0.46
Milk formula & milk products	0.00	0.17	0.28	0.42	1.26	0.58	0.01	0.06	0.14	0.41	0.76	0.17
Non-alcoholic beverages	0.21	0.31	0.44	0.55	0.78	0.54	0.23	0.31	0.35	0.56	0.83	0.37
Fats, oils & products	0.05	0.13	0.18	0.31	0.46	0.28	0.07	0.10	0.17	0.28	0.28	0.15
Sugars & sweets	0.08	0.05	0.05	0.09	0.11	0.08	0.07	0.09	0.07	0.10	0.12	0.08
Beans, nuts, seed products	0.01	0.01	0.02	0.07	0.12	0.06	0.01	0.27	0.12	0.02	0.14	0.10
Veg & fruit products	0.10	0.08	0.03	0.03	0.08	0.06	0.01	0.04	0.04	0.03	0.02	0.03
Alcoholic beverages	0.00	0.04	0.00	0.00	0.01	0.01	0.03	0.04	0.00	0.02	0.08	0.03
2. Minimally processed foods												
Fish, meat, poultry	2.17	3.52	4.30	4.55	5.93	4.61	2.14	3.08	4.09	5.51	6.68	3.63
Rice, cereals, starches	3.12	3.16	3.19	3.03	2.78	3.01	3.29	3.41	3.30	3.39	3.14	3.32
Veg & fruits	0.42	0.45	0.45	0.51	0.57	0.50	0.57	0.55	0.52	0.62	0.70	0.57
Milk	0.18	0.26	0.36	0.40	0.50	0.39	0.12	0.26	0.26	0.35	0.35	0.23
Beans, nuts, seeds	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.02	0.03	0.01	0.02

c. Foods that contribute significantly to the variance in per capita sodium intake

Table 3 shows the results of multiple regression analysis. A total of 15 foods (13 foods belonging to the processed food group, and 2 foods belonging to the minimally processed group) explained the variance in per capita sodium intake. Minimally processed foods that contributed significantly to sodium were cooked white rice and ready-to-eat prepared foods (fish, meat, poultry, organ meats). All other foods with significant contributions belonged to the processed food group. Among all minimally processed and processed foods, cooked white rice contributed the greatest amount of sodium (i.e., consumption of one gram of rice increased per capita sodium intake by 0.79 mg) followed by instant noodles (i.e., consumption of one gram instant noodles increased per capita sodium intake by 0.02 mg). This was followed by traditional condiments (fermented fish/seafood sauce), table salt, and processed meat, fish, poultry products.

Table 3
Food groups/subgroups and foods within each subgroup that contribute significantly to the variance in per capita sodium intake of Filipinos

R^2/Adjusted R^2 = 99.39%	Coefficient (b)	Linearized robust S.E.	p-value
A. **Processed foods**			
1. Instant noodles	0.019	0.001	0.000
2. Processed soup, sauces, flavor enhancers			
- Fermented fish/seafood sauce	0.011	0.003	0.001
- Table salt	0.011	0.003	0.000
3. Processed fish, meat, poultry products			
- Dried and smoked fish & seafood	0.010	0.003	0.004
- Canned & processed meat, fish, seafood	0.007	0.003	0.023
- Eggs salted	0.004	0.002	0.031
4. Alcoholic beverages	0.009	0.004	0.034
5. Baked products			
- White bread & *pandesal*	0.008	0.015	0.000
6. Other noodles & pasta			
- Noodles (wheat and egg)	0.006	0.003	0.016
7. Rice, cereal & starch products			
- Crispy cereal chips & extruded snacks	0.005	0.001	0.000
8. Fats, oils & products			
- Butter & margarine	0.005	0.002	0.010
9. Milk products			
- Cheese & fermented dairy products	0.004	0.001	0.011
10. Non-alcoholic beverages			
- Chocolate beverage	0.002	0.001	0.034
B. **Minimally processed foods**			
1. Rice, cereals, starches			
- Cooked white rice	0.790	0.267	0.003
2. Fish, meat, poultry			
- Prepared dishes (ready-to-eat)	0.010	0.004	0.012

Discussion

The prevalence of hypertension among adult Filipinos aged 20 years and above increased from 16% in 2003 to 21% in 2008 [4] to 28% in 2013 [5], highlighting the need to reduce sodium intake. The present study identified processed foods that can be targeted for reformulation to achieve reduced salt intake. Important sources of sodium were 13 foods in the processed food group and 2 foods in the minimally processed group, which together accounted for 99.4% of the variance in sodium intake of the entire population. In the processed foods group, the greatest contributors were the following: instant noodles and foods in the following categories: Processed Soup, Sauces & Flavor Enhancers (traditional fermented fish & seafood sauces, table salt); Processed Fish, Meat & Poultry Products (dried/smoked fish & seafood, canned & processed meat/fish/seafood, salted eggs); Baked Products (white bread, *pan de sal*); Other Noodles & Pasta (wheat and egg noodles); Rice, Cereal & Starch Products (crispy cereal chips and extruded snacks); Fats, Oils & Products (butter, margarine); Milk Products (cheese); Non-alcoholic Beverages (chocolate-based drinks).

Instant noodles. Estimated per capita consumption of instant noodles in 2008 was 2.86 kg/year [6] or approximately 8 g/day, contributing 158 mg Na/day. In 2017, instant noodles was the top noodle product consumed in the Philippines (consumed by 70.12% of households) [7]. Households consumed an average of 0.05 kg instant noodles per week or 2.69 kg a year. Rural households consumed greater amounts at 2.78 kg per year. During the same period, 27.6% of households reported substituting instant noodles for rice. The most frequent reason for substitution (reported by 18.43% of respondents) was that it is more affordable than rice [7]. Instant noodles contain ≈ 1975 mg Na/100 g [8]. Wheat and egg noodles (commonly called *pancit canton*) contain ≈ 1006 mg Na/100 g [9].

Processed soup, sauces and flavor enhancers. Within this category, table salt and traditional fermented fish/seafood sauces were the significant contributors to sodium intake. In 2008, coarse salt was the most commonly consumed condiment in the Philippines, with 64.9% of households consuming an average of 3 grams salt per day [10], equivalent to 1200 mg Na. Philippine shrimp paste contains 13–14 g Na/100 g [11]. The percentage of households consuming these traditional fermented foods in 2008 [12] was: *bagoong isda* (fermented anchovy), *ginamos* (fermented shrimp) – 10.1%; *patis* (fish sauce) – 6.1%; *bagoong alamang* (shrimp paste) – 4.7%. In a study among 1789 women, Lee found that salty condiments added during cooking or at the table accounted for 76.3% of sodium intake [13]. The most significant source of sodium was table salt, contributing 53.3% for women who consumed < 4600 mg/day of sodium and 66.5% for women who consumed higher amounts of sodium.

Pros and cons of indigenous fermented sauces

Traditional fermented salted products, while contributing significantly to sodium intake of Filipinos, are an important part of the food culture in the Philippines. Commonly used indigenous sauces are fermented fish and seafood sauces (*patis* or fish sauce, *bagoong* or fish/shrimp paste), soy sauce. These products are generally produced with high levels of salt, up to 25% for fish sauces and 11 to 25% for soy sauce [14] [15]. High levels of salt and low pH are important to suppress the growth of pathogenic microorganisms and enable bacterial degradation of proteins, carbohydrates, and nucleic acids. In spite of their high sodium content, these fermented sauces were shown to have functional effects. Japanese style fermented soy sauce (shoyu) showed antiallergic, antimicrobial, antihypertensive, and anticarcinogenic effects [16] [17]. Fermented foods contain live microorganisms and therefore comprise a good source of probiotics. Lactic acid bacteria were found in fermented fish (ranging from 3.48 to 5.43 log cfu/g) while aerobic bacteria were found in fish sauce (ranging from 4.92 to 5.53 log cfu/g [18]). Fermentation-derived microorganisms have the potential to influence gut microbiota diversity, structure, and function and increase the amount of nutrients such as vitamins and other bioactive molecules produced from microbial metabolism that are not present in the original food [18]. These bacteria may also secrete anti-microbial agents, degrade anti-nutritive compounds, produce short-chain fatty acids from indigestible carbohydrates, and contribute to immune homeostasis [18] [19] [20]. A study on the composition of shrimp pastes produced in some parts of the Philippines showed these foods were good sources of omega-3 fatty acids, iron, zinc, and calcium [11]. Due to their extensive use, fortification of condiments and seasonings is also seen as a cost-effective intervention to address micronutrient deficiencies in Southeast Asia [21] [22]. Studies in young children and adult women suggested that fortification of sauces (fish sauce, soy sauce) can effectively address iron and iodine deficiencies [23] [24].

Processed fish, meat, poultry products. Foods that contributed significantly to sodium intake were dried/smoked fish and seafood, canned/processed meat, fish & seafood, and salted eggs. In 2008, consumption of fish and fish products was 110 grams per capita. Canned sardines (containing approximately 521 mg Na/100g) [8] was consumed by 15.3% of households with mean consumption of 8 grams per capita per day [10]. Dried and smoked fish was consumed by 20.5% of households [12]. Dried fish contains ≈ 7000 mg Na per 100 g [25]. Filipinos aged 60 + years ate the most fish and fish products (15.6% of total food consumption), followed by those aged 20 to 59 years (14.7% of total consumption) [12].

Consumption of meat and meat products in 2008 was 83 grams per capita. The Family Income and Expenditure Survey (FIES) showed that household food expenditures on meats increased by 4 to 5 percentage points from 1965 to 2000. The biggest growth in expenditure was for processed meats, increasing by 2.7% during the same period [26]. In 2003, processed meat products (hotdogs, meatloaf, sausages) represented nearly 30% of per capita meat intake [27].

Limitations of the study

The study examined only 2008 national food consumption data. Data from multiple successive surveys should be examined since the market for processed foods is dynamic, with products constantly being introduced, reformulated, or taken out. In spite of this, the present study is the currently the only one that identifies sodium-contributing foods for development of population sodium reduction initiatives. The consumption of processed foods among Filipinos has increased over time. For instance, the demand for instant noodles in the Philippines increased from 3400 million servings in 2016 to 4470 million servings in 2020 [28]. For processed meat, the average volume per person is expected to amount to 3.9 kg in 2021 and the market is expected to grow annually by 1.89% from 2021 to 2025 [29]. During this pandemic, sodium intake is expected to increase further. Food relief packs distributed nationwide by the Department of Social Welfare and Development contain rice,

corned beef, sardines, and chocolate energy drink or coffee [30]. Corned beef, sardines, and chocolate beverage are among the foods identified in this study which significantly contribute to the variance in sodium intake of Filipinos.

Conclusions

Indicator foods that can be targeted for reformulation to reduce population sodium intake among Filipinos are instant noodles, traditional fermented condiments and sauces, and processed meat, fish, and poultry products. Other processed foods with significant contributions to the variance in sodium intake and whose consumption can be reduced via consumer education and reformulation (e.g., "stealth" reductions) are table salt, alcoholic beverages, white bread and *pan de sal* (a traditional bread), crispy cereal chips and extruded snacks, butter and margarine, cheese, and chocolate based beverages.

Methods

Aim, design and setting. The study identified processed foods that can be targeted for reformulation and whose sodium content can be monitored over time to achieve reduced sodium intake in the Philippines. This cross-sectional study examined per capita food consumption obtained from one-day household food weighing data of 4880 households participating in the 2008 National Nutrition Survey.

Sampling method. The 2008 National Nutrition Survey used a stratified multi-stage sampling design. In the first stage, primary sampling units were selected from 17 regions and 79 provinces throughout the country. In the second stage, enumeration areas were identified from primary sampling units. Finally specific households from each enumeration area were selected, comprising a total of 4880 households (median 5 members per household) nationwide.

Characteristics of the sample. The sample comprised 43% urban and 57% rural households with more households belonging to lower income groups, reflecting the country's socioeconomic classification as a low middle income country. Table 4 shows the distribution of households by location of residence and wealth quintile.

Table 4
Distribution of sample households. Philippines 2008

	Urban		**Rural**		**Both**	
Wealth quintile	No.	%	No.	%	No.	%
Q0 (unidentified)	5	0	7	0	12	0
Q1 (lowest)	167	3	945	19	1112	23
Q2	351	7	685	14	1036	21
Q3	466	10	511	10	977	20
Q4	540	11	403	8	943	19
Q5 (highest)	592	12	208	4	800	16
All	2121	43	2759	57	4880	100
Median number of household members = 5						

Data collection. One-day household weighing of food items from breakfast through supper, including snacks was conducted. Digital dietetic scales were calibrated using a one-kg standard weight. On the day of weighing, all items were weighed before cooking or serving including: *raw as purchased* foods to be cooked for each meal and snacks, food served and eaten raw, cooked and processed foodstuff served directly on the dining table. Leftover foods were weighed and, together with the weights of plate wastes and foods given out, were deducted from the sum of weighed food to obtain the actual amount of food consumed by the household [31]. A food inventory was also conducted. Non-perishable food items that might be used anytime of the day such as coffee, sugar, salt, cooking oil, and other condiments were weighed at the beginning and end of the food weighing day. Foods eaten by household members who ate outside their homes were recalled and recorded to complete the household's food record. Sample weighing of similar food items eaten out was performed for validation purposes [31].

Data analysis. Prior to statistical analysis, the following steps were taken: 1) Creation of a food composition database for sodium; 2) Grouping of all foods consumed into 2 categories: Minimally Processed Foods and Processed Foods/Food Products.

Development of a food composition database for sodium. The Philippine food composition table does not provide nutrient values for sodium. Hence, the sodium content of all foods consumed was estimated from values derived from different food composition tables, using the process described by INFOODS. The INFOODS guidelines for food matching [32] guided the selection of appropriate foods from which to borrow sodium values, in the most appropriate source of compositional data. Values for sodium consumption were then computed by multiplying each food's sodium content by the amount consumed by the entire household.

Grouping of foods into minimally processed and processed food categories. Almost all foods consumed in the Filipino diet are processed or cooked to a certain extent prior to ingestion. FAO [33] recommended that the level of food processing should be taken into account when examining food consumption data, so as to inform the development and implementation of food-based guidelines and approaches to the prevention of chronic diseases. The NOVA food classification system [33] [34] developed by researchers in Brazil, classifies foods according to the nature, degree, and purpose of processing. The present study used a modified version of the NOVA classification wherein foods were classified into two main groups and each group was further classified into subgroups:

1) Minimally Processed Foods (subgroups comprised cooked/prepared whole foods, e.g., boiled rice and tubers, whole fish/meat/chicken dishes, milk (fresh liquid and whole milk powder), raw or cooked whole vegetables and fruits), and

2) Processed Foods (subgroups comprised processed and preserved/salted food products, foods made from processed ingredients).

All foods consumed by survey households were listed. Similar foods were grouped into specific subgroups (a total of 18 subgroups or categories were created for 1306 individual food items). Each food category was classified as belonging to either the minimally processed or processed groups (shown in Table 5). This classification was done to allow the development of recommendations for sodium reduction that correspond to dietary patterns of the entire population.

Table 5
Minimally processed and processed foods consumed by the population, Philippines 2008

	Percentage contribution to mean per capita Na intake (%)											
	Urban households						Rural households					
	Q1	Q2	Q3	Q4	Q5	All	Q1	Q2	Q3	Q4	Q5	All
A. Processed foods												
Processed soup, sauces & flavor enhancers	57.96	55.86	58.14	73.20	76.56	67.36	71.62	72.7	74.93	79.39	97.41	75.83
Processed fish, meat & poultry products	7.37	8.77	9.96	11.53	12.34	10.75	7.41	9.10	9.70	11.29	9.90	9.08
Baked products	1.55	3.85	4.82	5.85	7.83	5.66	1.01	1.71	2.80	3.75	6.48	2.40
Instant noodles	3.33	3.93	3.87	3.21	3.04	3.45	3.94	4.37	3.82	3.52	3.09	3.89
Other noodles & pasta	0.46	0.68	1.02	0.93	1.07	0.92	0.47	0.51	0.70	0.99	1.37	0.68
Rice, cereal, starch products	0.38	0.50	0.56	0.80	0.83	0.68	0.26	0.52	0.46	0.54	0.96	0.46
Milk formula & milk products	0.00	0.17	0.28	0.42	1.26	0.58	0.01	0.06	0.14	0.41	0.76	0.17
Non-alcoholic beverages	0.21	0.31	0.44	0.55	0.78	0.54	0.23	0.31	0.35	0.56	0.83	0.37
Fats, oils & products	0.05	0.13	0.18	0.31	0.46	0.28	0.07	0.10	0.17	0.28	0.28	0.15
Sugars & sweets	0.08	0.05	0.05	0.09	0.11	0.08	0.07	0.09	0.07	0.10	0.12	0.08
Beans, nuts, seed products	0.01	0.01	0.02	0.07	0.12	0.06	0.01	0.27	0.12	0.02	0.14	0.10
Veg & fruit products	0.10	0.08	0.03	0.03	0.08	0.06	0.01	0.04	0.04	0.03	0.02	0.03
Alcoholic beverages	0.00	0.04	0.00	0.00	0.01	0.01	0.03	0.04	0.00	0.02	0.08	0.03
B. Minimally processed foods												
Fish, meat, poultry	2.17	3.52	4.30	4.55	5.93	4.61	2.14	3.08	4.09	5.51	6.68	3.63
Rice, cereals, starches	3.12	3.16	3.19	3.03	2.78	3.01	3.29	3.41	3.30	3.39	3.14	3.32
Veg & fruits	0.42	0.45	0.45	0.51	0.57	0.50	0.57	0.55	0.52	0.62	0.70	0.57
Milk	0.18	0.26	0.36	0.40	0.50	0.39	0.12	0.26	0.26	0.35	0.35	0.23
Beans, nuts, seeds	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.02	0.03	0.01	0.02

Main food groups & categories	Foods in each category
A. **Minimally processed foods**	
1. Fish, meat, poultry	Fresh meat, poultry, organ meat
	Fresh fish & seafood
	Prepared dishes ready-to-eat
	Unsalted fresh eggs
2. Rice, cereals, starches	Cooked rice
	Corn & other cereals
	Starchy roots & tubers
3. Vegetables & fruits	Fresh fruits & vegetables
	Seaweed dried & fresh
	Sundried & cooked fruits
4. Beans, nuts, seeds	Cooked beans, nuts, seeds dishes
5. Milk	Liquid milk (fresh, evaporated, recombined);
	Milk powder (whole, full cream, filled);
	Skimmed milk
	Fermented milk
B. **Processed foods/food products**	
6. Processed fish, meat & poultry products	Canned & processed meat, fish, seafood
	Dried & smoked fish & seafood
	Salted eggs
7. Baked products	White bread & pan de sal
	Sweet breads
	Biscuits, crackers, cookies
	Cakes, pies, pastries
8. Instant noodles	Instant noodles
9. Processed soup, sauces, flavor enhancers	Soup powder
	Fermented fish & seafood sauce
	Salt
	MSG and MSG-containing cubes
10. Other noodles & pasta	Wheat & egg noodles
	rice & mungbean noodles
11. Rice, cereal, starch products	Sweetened rice cakes & snacks
	sweet popcorn
	crispy cereal chips & extruded snacks
	breakfast cereal
	cassava cake & snacks
	infant cereal
	starch wrappers

Main food groups & categories	Foods in each category
12. Non-alcoholic beverages	Coffee/ tea
	Chocolate beverage
	Sweetened juice & other sweet drinks
	Softdrink
13. Fats, oils, & products	Cooking oil & lard
	Creamers & cream
	Butter & margarine
	Peanut butter, mayonnaise & spreads
14. Sugars & sweets	Sugar (refined, second class, crude)
	Candies & jams
15. Milk formula & milk products	Milk formula for adults, infants & children
	Ice cream & dairy products
	Cheese & fermented dairy products
	Condensed milk
16. Alcoholic beverages	Beer & indigenous alcoholic beverages
17. Vegetable & fruit products	Canned fruit & fruit juice
	Canned vegetables
	Preserved fruits
18. Beans, nuts & seed products	Soyfoods & beverages
	Salted nuts & seeds

Statistical analysis.

Per capita consumption of sodium from different food subcategories was obtained by summing the total amount of sodium (in milligrams) ingested by the entire household divided by the number of consumption units. Percentiles of sodium intake (P25, P50, P75, P99) from different food subcategories and interquartile range (IQR) were obtained using STATA. The percentage contribution of different food categories to mean per capita intake was calculated using the ratio of means wherein mean sodium intake from a specific category was divided by mean per capita sodium intake.

Multiple regression analysis was used to identify specific foods that contributed to the variance in sodium intake for the entire population. Sodium intake values from specific foods in the different categories shown in Table 5 were transformed logarithmically. Thus the form of the regression model fitted is

$$\log Sodium = \beta_o + \beta_1 \log V_1 + \beta_2 \log V_2 + \cdots + \beta_p \log V_p + \varepsilon$$

where $V_1, V_2, \ldots, V_p$ are the milligram consumption in different foods across food groups, and ε is the error term that represents

different foods across food groups, and **ε** is the error term that represents the variation not due to food consumption, including measurement errors. The significant variables were obtained by backward elimination. Variables in the equation were retained at 5% level of significance. To account for heteroskedasticity, the linearized robust standard errors were produced. Outliers and influential observations were excluded from the analysis.

Declarations

- *Ethics approval and consent to participate*

The study used secondary data hence ethical approval was not required. The Philippines National Nutrition Surveys are approved by the Food and Nutrition Research Institute's Institutional Ethics Review Board. All participants sign a consent form prior to participation.

- *Consent for publication*

Not applicable

- *Availability of data and materials*

The datasets generated and/or analysed during the current study are not publicly available due to [INTELLECTUAL PROPERTY CLAIMS BY FOOD AND NUTRITION RESEARCH INSTITUTE]. Data are available from Mr. Glen Gironella (email glengironella@gmail.com) upon request and payment of a fee set by the Institute.

- *Competing interests*

MVC and GG received funding support from International Life Sciences Institute Southeast Asia Region. MSA and FDLR have no conflict of interest to declare.

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- *Authors' contributions*

MSA conceptualized the study and wrote the manuscript. FDLR and GG processed and analysed the data. MVC reviewed the final draft of the manuscript. All authors read and approved the final manuscript.

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