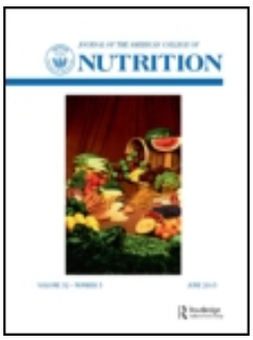

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Relative Contributions of Dietary Sodium Sources

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Key words: salt intake, sodium, dietary, sodium sources

Information on the relative contributions of all dietary sodium (Na) sources is needed to assess the potential efficacy of manipulating the component parts in efforts to implement current recommendations to reduce Na intake in the population. The present study quantified the contributions of inherently food-borne, processing-added, table, cooking, and water sources in 62 adults who were regular users of discretionary salt to allow such an assessment. Seven-day dietary records, potable water collections, and preweighed salt shakers were used to estimate Na intake. Na added during processing contributed 77% of total intake, 11.6% was derived from Na inherent to food, and water was a trivial source. The observed table (6.2%) and cooking (5.1%) values may overestimate the contribution of these sources in the general population due to sample characteristics, yet they were still markedly lower than previously reported values. These findings, coupled with similar observations from other studies, indicate that reduction of discretionary salt will contribute little to moderation of total Na intake in the population.

Abbreviations: ANOVA = analysis of variance, CI = confidence interval, CV = coefficient of variance, Na = sodium, NaCl = salt, $NaCl_{cook}$ = cooking salt, $NaCl_{tab}$ = table salt, NFCS = Nationwide Food Consumption Survey

INTRODUCTION

Implementation of recommendations to reduce sodium (Na) intake in the US population [1–5] will require knowledge of the relative contributions of all dietary sources of this nutrient. The principal sources include: Na inherent to foods, Na added during food processing, discretionary salt (NaCl) use (i.e., table and cooking), water, and pharmaceuticals. Nationwide dietary studies [6–8] have provided important insights on the Na contributions of specific foods and food groups, but there has been no attempt to differentiate between the inherent and processing-added Na content of foods in these efforts, nor have other dietary sources been monitored. Contributions from additional selected sources have been reported (Table 1), but in no case has the contribution of all individual sources been monitored in a single US population. The purpose of the present study was to simultaneously quantify the contribution of each dietary Na source among a population of healthy normotensive adults who regularly used $NaCl_{tab}$ (table salt) and $NaCl_{cook}$ (cooking salt) and made no conscious attempt to limit ingestion of salty-tasting or Na-dense foods. Such a sample was viewed as a likely target for nutrition education efforts aimed at reducing Na intake. Similar additional work, if based upon other well-defined segments of the population, should provide a more sound basis for formulating dietary prescriptions and nutrition policy with respect to Na.

The data compiled in Table 1 highlight the wide variability of estimates for different sources and, as a consequence, the danger of making generalizations. This variability is attributable to many methodological factors: most notably, differences in study population, data source, and time frame. For example, data on water as a source of Na are derived principally from studies assessing the relationship between water composition and cardiovascular disease. To facilitate such work, researchers have commonly sought out communities with widely discrepant source levels. With regard to NaCl use, estimates based upon salt purchases are generally higher than those derived from controlled dietary intake studies. This difference is presumably attributable to the fact that a substantial amount of salt is used for nondietary purposes. Finally, discrepant estimates may reflect true differences in use between times of evaluation. While sale

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Table 1. Percentage Contributions of Dietary Sources of Sodium in US Studies and Selected Western Nations[a]

Ref	Year	Water	Inherent	Processing	Cooking	Table
United States						
9	1958		27			
10	1979		25–30	35–45	35–45[b]	
11	1973				45	
12	1982				10	
13	1983					10–25
14	1986					13
15	1986					3–9
16	1984					3
17	1987					2
18	1987					1
19	1980	4–27				
20	1986	12–25				
21	1983	1–14				
22	1961	1–9				
23	1981	1–4				
24	1982	2				
United Kingdom						
25	1983				10	16
26	1980		10	58	32	
27	1987				5	10
28	1986				5	7
Finland						
29,30	1981–82		13	44	40	
Sweden						
31	1973		8	47	45	
Canada						
32,33	1982–83		17			
Australia						
34	1984				80[c]	
35	1984					19

[a]Values correspond to reported mean intake level for each source.

[b]Values in this column relate to cooking and table sources.

[c]This value relates to processing, cooking, and table sources.

figures of food-grade salt are an imperfect index of Na intake, such sales declined 36% between 1972 and 1985 [36]. The higher discretionary salt use figures were released in the 1970s [10,11], whereas the lower estimates are more recent [12,15–17].

Estimates for the US population differ markedly from those of several other Western nations. The most commonly cited estimates [5,10] of inherent and processing-added Na are that each contributes about 30–35% of total intake in the United States. Figures from other nations indicate these sources contribute over 50% and perhaps as high as 85% (Table 1) if it is assumed that water and pharmaceutical sources are small. Estimated combined $NaCl_{tab}$ and $NaCl_{cook}$ is more than 50% higher in the United States than in England, where particularly good data have been obtained [27], and 10% less than that reported from Finland or Sweden. Whether these differences are true or an artifact (as the present data suggest) holds important clinical and health policy implications. For example, if present US estimates for $NaCl_{tab}$ and $NaCl_{cook}$ use are erroneously high, recommendations to moderate Na intake to 1.1–3.3 g/day by limit-

Table 2. Selected Subject (n = 62) Characteristics Expressed as Mean ± SD

Age (years)	30.1 ± 9.0
Sex (M/F)	16/46
Race (black/white/Native American/unknown)	14/44/3/1
Height (m)	1.67 ± 0.01
Weight (kg)	67.7 ± 13.3
Blood pressure (systolic/diastolic, mm Hg)	109 ± 12.0/69 ± 10.7

ing these sources, as suggested in the recent Surgeon General's Report [5] and the 1980 Recommended Dietary Allowances [37] (not addressed in the 1989 RDAs) may be unfruitful. If US estimates of processing-added salt are inappropriately low, attention focusing on industry's role in moderating the population's Na intake may need to be expanded.

METHODS

General Protocol

Sixty-two participants, recruited by public advertisement, provided health and demographic information by questionnaire at the initial meeting. They then received counseling by a nutritionist on recording of dietary intake, urine collection, and salt shaker use. This was followed by measurement of height, weight, and blood pressure (with a mercury sphygmomanometer using Korotkoff sounds I and V). After the meeting, they recorded food intake and used assigned preweighed salt shakers for cooking and table seasoning for 7 consecutive days. Urine collection occurred on days 5 and 6 of the 7-day period. On day 7, subjects delivered their urine samples and met with the nutritionist to review their dietary record, and salt shakers were weighed. To assess the reliability of intake estimates, these procedures were repeated in a random sample of 20 of the 62 subjects 8 and 25 weeks later. Data from the other 42 subjects are not included in this report because their intake was experimentally manipulated after the 7-day baseline period. This study was approved by the Committee on Studies Involving Human Beings at the University of Pennsylvania.

Subjects

Selected characteristics of the participants are listed in Table 2. They were all apparently healthy and were not adhering to any therapeutic diet. Each had control over the addition of salt when cooking (i.e., < 3 meals/week were eaten away from home and they prepared their own meals at home). Subjects also indicated that they routinely added salt to their food when cooking and at the table.

Measures of Na Intake

Inherent and Processing-Added Sodium

These sources of Na were determined by 7-day diet records. Subjects were taught to keep a record and estimate portion sizes using food models, cooking utensils, and printed materials. The data were analyzed using version 3.0 of the Nutritionist III nutrient database software package (N-Squared Computing, Silverton, OR). The core database was supplemented with information obtained from manufacturers and franchise restaurants. One individual coded all diet records and developed a list of standard substitutions for items not included in the database. All records were coded using (1) all foods and beverages entered as the constituent ingredients in unprocessed form (e.g., chips: potato, oil) and (2) values for the processed versions (e.g., chips: potato, oil, NaCl). The former was subtracted from the latter to derive an estimate of the Na contributed by processing. The levels of protein, carbohydrate, fat, alcohol, and total energy of the two separate diet analyses agreed to within 5%, ensuring that differences were not attributable to loss of other food data.

$NaCl_{tab}$ and $NaCl_{cook}$ Use

This is comprised of Na obtained through salt use during food preparation in the home (cooking salt, $NaCl_{cook}$) as well as salt added at the table (table salt, $NaCl_{tab}$). Na contributed by other seasonings was not monitored, but a review of the diet records, where use of

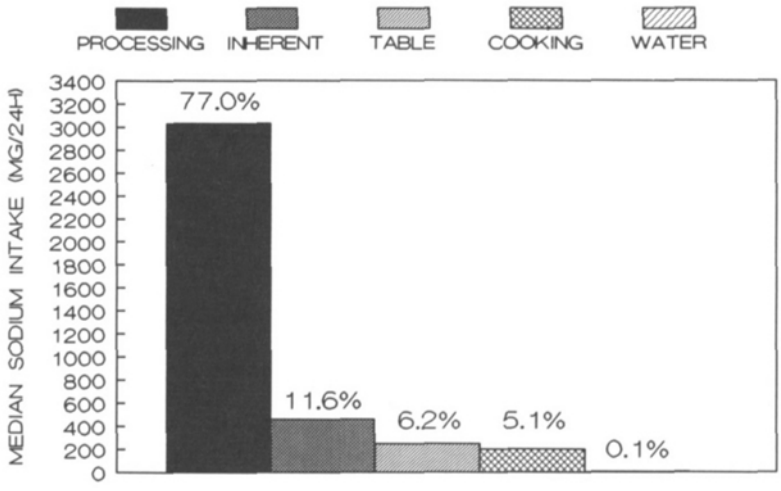

Fig. 1. Observed contributions of dietary sodium sources to total sodium intake.

such products should have been recorded, indicated that this was a trivial source among study participants. Subjects were provided with weighed shakers labeled "cooking salt" and "table salt" with snap-on caps to avoid spillage. They were instructed to use the shakers in their customary manner. The table salt shaker was carried at all times to allow salting of foods ingested away from home. Shakers were reweighed after week 1. In the random subsample, shakers were also weighed after weeks 8 and 25 to determine the quantity used.

Midway through the study, lithium carbonate was added to the two salt shakers and urinary lithium excretion was monitored as a check on the validity of estimated $NaCl_{tab/cook}$ use. The method of Sanchez-Castillo et al [38] was used to prepare the marked salt, and the urinary concentration of lithium was determined by flame photometry. Because the original protocol called for only two 24-hr urine collections and could not be changed in midstudy, this procedure did not permit quantitative determination of $NaCl_{tab/cook}$ use. Six to nine consecutive 24-hr urine collections would be required to quantitatively collect the lithium marker and allow a more precise estimate of Na intake. However, the procedure did offer a crude index for checking the validity of estimated intake from discretionary sources. Data were obtained from 15 of 20 subjects in the subsample followed for 26 weeks.

Water Na

Subjects were provided with plastic containers and a graduated cylinder and instructed to collect a duplicate portion of all water ingested as a beverage over a 3-day period. The total volume was recorded, the Na content determined by flame photometry, and an mEq Na/24 hr value was computed. Three 24-hr collections are reported to provide a stable estimate of water usage [39].

Pharmaceutical Na

This source was not quantified since "good health" was an eligibility criterion. Thus, other than an occasional over-the-counter analgesic, few medications were used. Antacids may be a major contributor of Na in this category, but our subjects did not report use of this source.

Total Na Intake

This was the sum of dietary estimates of all contributory sources. To corroborate this estimate, two 24-hr urine samples were collected at the end of baseline, week 8, and week 25 and were analyzed for Na by flame photometry and creatinine by colorimetry (Sigma diagnostic kit 555-A). Urines containing less than 0.6 g creatinine/24 hr or more than 3.4 g creatinine/24 hr were deemed unreliable (6.7% of samples) and excluded from analyses.

Statistical Analyses

Pearson correlation coefficients were computed to assess relationships among and between subjects and intake measures. Subgroup (e.g., male vs female, random subgroup vs total sample) differences were evaluated with Student's t-tests. Levels of NaCl use over time were examined by repeated measures analysis of variance (ANOVA). Parametric tests were used since variable dis-

Table 3. Computed Intra- and Intersubject Coefficients of Variation (SD/Mean) for Dietary Sodium Sources

Intake sodium source	Intrasubject	Intersubject
Coefficient of variation for 7-day means		
Processing-added	23.3%	30.9%
Inherent	27.7%	19.4%
Table	79.4%	141.7%
Cooking	97.7%	187.7%
Total	19.5%	39.3%
Coefficient of variation for daily sodium		
Processing-added	45.6%	45.0%
Inherent	45.0%	55.7%

tributions were approximately normal and these procedures are reasonably robust with an adequate sample size. The coefficient of variation (standard deviation/mean) was computed as an index of the variability of intake from each dietary Na source. To assess the test–retest reliability of the data, correlations (Pearson) between values obtained at baseline and week 26 were computed. The validity of the dietary data was checked by computing correlations between dietary Na estimates and urinary excretion levels of Na and a lithium marker. The value $p < 0.05$ defined statistical significance.

RESULTS

Dietary Na Intake

Median total dietary Na intake was 3938 mg/24 hr. Estimated contributions of each source are presented in Figure 1. Processing-added Na was clearly the major contributor of Na in the diets of our participants (77% of total intake). It contributed more than half of total intake in 84% (52/62) of participants. Na naturally inherent in foods was the second largest source (11.6%). Only 3% (2/62) of subjects obtained less than 5% of dietary Na from this source and approximately 5% (3/62) derived over 15% from salt inherent to foods. Table and cooking sources were comparable in size; combined they contributed 11.3% of total Na intake. Water was found to be a trivial source of dietary Na. Mean values for processing-added (3168 mg/day), naturally inherent (488 mg/day), and water (11 mg/day) sources were comparable to median values (Fig. 1), but due to three outliers for table salt and four outliers for cooking salt, mean values for these sources were 2–3 times higher than the medians. The mean (SD) value for table salt was 581 ± 849 mg/day and cooking salt was 684 ± 1009 mg/day.

Females ingested significantly less total Na ($t = 2.50$, $p = 0.02$), inherent Na ($t = 2.39$, $p = 0.026$), and processing-added Na ($t = 2.34$, $p = 0.026$) than males. However, this was likely due to gender-based differences in energy intake since the mean Na density of male and female diets were similar at 2229 mg Na/1000 kcal and 2025 mg Na/1000 kcal, respectively.

Coefficients of Variation for Dietary Na Sources

The intra- and intersubject coefficient of variation (CV = standard deviation/mean) was computed for each Na component using the random sample of 20 subjects. These individuals did not differ from the total sample in age, sex ratio, weight, blood pressure, or dietary intake of macronutrients, Na, potassium, calcium, or magnesium. For $NaCl_{tab}$ and $NaCl_{cook}$ use, this comparison was based upon seven 7-day means. Daily processing-added and inherent Na values were available from the diet records. The CV was computed using daily estimates, as well as three 7-day means (to allow direct comparisons with the discretionary sources). With the exception of inherent Na, within-subject variability based upon the 7-day means was less than that noted between subjects (Table 3). The intra- and intersubject CV associated with processing-added and inherent sources, determined from daily intake data, were comparable; however, as expected, the absolute values of the variance estimates were lower for the 7-day mean data.

The 95% confidence intervals (CI) were computed for each individual (Table 4) and the group (Table 5) based upon one, three, or five 7-day monitoring periods. These

Table 4. Individual 95th Percentile Confidence Intervals for Dietary Sodium Sources and Total Sodium Intake Based upon 7-Day Mean Food Intake Records[a]

	Table					Cooking					Processing-added					Inherent					Total				
			95% CI Replicate					95% CI Replicate					95% CI Replicate					95% CI Replicate					95% CI Replicate	
ID	Mean (mg Na)	CV	1	3	5	Mean (mg Na)	CV	1	3	5	Mean (mg Na)	CV	1	3	5	Mean (mg Na)	CV	1	3	5	Mean (mg Na)	CV	1	3	5
1	46	120	239	138	107	369	165	331	191	148	2812	10	21	12	9	512	31	62	36	28	3466	13	26	15	12
2	346	45	90	52	40	397	59	119	69	53	2913	38	76	44	34	455	26	51	29	23	4216	32	64	37	29
3	17	59	118	68	53	5868	65	130	75	58	4236	17	34	20	15	623	12	24	14	11	9829	22	45	26	20
4	417	50	99	57	44	767	37	75	43	33	2319	12	23	13	10	430	30	60	35	27	3794	11	21	12	9
5	59	76	153	88	68	217	91	182	105	81	2382	6	12	7	5	427	8	17	10	7	3125	15	30	17	13
6	434	52	104	60	47	70	99	197	114	88	2812	6	11	6	5	498	16	32	18	14	3816	5	9	5	4
7	306	218	436	252	195	39	149	297	172	133	2148	25	51	29	23	427	22	43	25	19	3195	15	29	17	13
8	589	65	130	75	58	—	—	—	—	—	3088	23	46	26	20	412	16	32	19	14	4163	28	57	33	25
9	301	36	72	42	32	104	62	123	71	55	2684	30	60	35	27	366	15	30	17	14	3479	24	49	28	2
10	234	37	74	42	33	277	65	129	75	58	2858	10	20	11	9	490	17	34	20	15	3927	15	30	17	3
11	1676	64	129	74	58	2393	59	119	69	53	1701	73	145	84	65	791	80	161	93	72	7250	4	82	47	6
12	197	30	61	35	27	150	123	245	142	110	2025	16	32	18	14	255	33	66	38	30	2676	18	36	21	6
13	656	28	56	32	25	376	66	132	76	59	2741	26	52	30	23	382	29	59	34	26	4060	17	35	20	6
14	153	89	178	103	80	451	144	289	167	129	3705	14	28	16	12	461	21	42	24	19	4417	18	35	20	6
15	10	240	480	277	215	2	200	400	231	179	2705	41	82	48	37	442	24	47	27	21	3199	38	76	44	4
16	149	58	115	67	52	404	77	154	89	69	1827	18	35	20	16	392	4	8	5	4	2780	9	18	10	8
17	269	41	83	48	37	466	88	177	102	79	3191	26	52	30	23	508	40	80	46	36	4399	16	33	19	5
18	59	80	159	92	71	13	139	277	160	124	2609	23	45	26	20	334	35	70	41	31	3022	15	29	17	3
19	143	130	260	150	116	109	87	174	101	78	3315	22	44	25	19	435	53	107	62	48	3979	18	36	21	6
20	361	71	142	82	64	266	82	163	94	73	3612	31	61	35	27	516	42	83	48	37	4981	20	40	23	8
Mean											2776	23	44	26	20	438	28	49	28	22	3872	20	35	20	6

[a]Ranges may be determined by computing the mean ± CI. Values are computed assuming the availability of 1, 3, or 5 7-day records.

Table 5. Group 95th Percentile Confidence Intervals for Dietary Sodium Sources and Total Sodium Intake Based upon 7-Day Mean Food Intake Records[a]

	Coefficient of variation Sodium source				
Replicate	Processing-added	Inherent	Table	Cooking	Total
1	32.9	30.7	66.5	75.5	34.3
3	27.8	23.9	58.0	66.4	30.3
5	26.7	22.3	56.1	64.4	29.4

[a]Ranges may be determined by computing the mean ± CI. Values are computed assuming the availability of 1, 3, or 5 7-day records.

data reveal a high level of uncertainty for estimates of $NaCl_{tab}$ and $NaCl_{cook}$ use. In no individual case could a single 7-day mean usage value for either table or cooking salt be assumed to lie within 50% of the observed mean with 95% confidence. Indeed, for the majority of individuals, the 95% CI for Na intake exceeded 100% of a single 7-day mean and 50% of five 7-day means. For estimated contributions of processing-added or inherent Na, individual 95% CI generally exceeded 20% of the single 7-day mean. An individual's true mean intake from these sources can only be estimated to lie within ± 20 and ± 22% of his or her observed mean with 95% confidence after collection of five 7-day intake data. With respect to total Na intake, the mean individual CV was 19.5%, so that a 7-day data collection would allow estimation of an individual's true mean total Na intake to fall within 35% of the observed mean with 95% confidence. Five 7-day collections are needed to reduce the 95% CI for total Na intake to less than 10%.

Correlations Among Dietary Variables

Significant associations were observed between $NaCl_{tab}$ and $NaCl_{cook}$ use ($r = 0.32$, $p < 0.05$) and between intake of inherent and processing-added sources ($r = 0.53$, $p < 0.001$). Neither discretionary source was significantly associated with processing-added or inherent sources. Since total Na was computed by adding the contributions of each constituent source, all were significantly associated with the total.

Reliability and Validity

Correlations between values obtained at baseline and week 25 were examined to assess the reliability of source estimates. With the exception of estimated inherent intake, significant associations (all $p < 0.001$) were noted with correlation coefficients ranging from 0.43 to 0.68. A repeated measures ANOVA did not reveal significant changes in the use of any source over the 26-week study.

Supporting the validity of the dietary data, urinary excretion values were significantly correlated with total dietary Na and processing-added Na (both $r = 0.31$, $p < 0.05$). The urinary value (2926 mg/24 hr) was approximately 74% of the reported dietary estimate. Previous balance studies with individuals consuming diets similar to those of our subjects observed urinary excretion rates corresponding to 80–86% of values from diet records [40,41]. A significant correlation was observed between urinary lithium levels and total NaCl use ($r = 0.64$, $p < 0.001$). An association was also noted with $NaCl_{tab}$ alone ($r = 0.62$, $p < 0.001$), but not with $NaCl_{cook}$ alone. This may reflect the greater potential for losses with $NaCl_{cook}$ as variable amounts are knowingly discarded and/or consumed by others.

DISCUSSION

This study is the first to simultaneously assess the contributions of all significant Na sources in a US population sample. The principal finding is that discretionary sources contribute less dietary Na than commonly believed. In contrast to the estimated 33% contribution reported by the recent Surgeon General's Report on Nutrition and Health [5] and other sources [10,11], we found $NaCl_{tab}$ and $NaCl_{cook}$ to contribute only 11.3% of total Na intake. This estimate is probably high, too, since we did not adjust for spillage, $NaCl_{cook}$ consumed by others, or amounts discarded in cooking water. Based upon work in England which indicates only approximately 24% of $NaCl_{cook}$ is ingested [27], cooking

and total discretionary Na in the present study could more appropriately be estimated at 1.3 and 7.5%, respectively. It should also be noted that study participants were recruited only if they used both $NaCl_{tab}$ and $NaCl_{cook}$. Thirty percent of all respondents to recruitment ads indicated that they never used table or cooking salt. Others have also reported that between one-third and two-thirds of their selected study populations report no use of $NaCl_{tab}$ [42–46]. Assuming this body of data provides insights to the habits of the population as a whole, the present figures of 1.3 and 7.5% for $NaCl_{cook}$ and combined $NaCl_{tab}$ and $NaCl_{cook}$ are still overestimates. The true contribution of this source in the general population may well be below 5% of total Na intake. Other recent studies have obtained similar results. Witschi et al [18] reported $NaCl_{tab}$ contributed only 1% of dietary Na among 200 boarding school students; Beauchamp et al [17] noted that undergraduate students added only 2% at the table, and a value of 3% has been reported by Holbrook et al [16] among adults. Thus, accumulating evidence indicates that $NaCl_{tab}$ and $NaCl_{cook}$ make only a minor contribution to total Na intake.

Our findings are also in close agreement with recent reports on Na intake from other Western nations. Approximately 80% of Na intake is reportedly derived from nondiscretionary sources in Britain [27,47], Canada [32,33], and Australia [34].

The present data indicate that gender-based differences in Na intake are related to energy consumption. The Na density of the male and female diets were similar. The lack of a gender difference has been noted in other clinical studies [16,48], as well as in large epidemiological studies [7].

The observed variability for source estimates is also generally consistent with values reported in the literature. Our intrasubject CV for nondiscretionary sources of about 45% agrees with the values of 43 and 40% obtained by Caggiula et al [49] and interpolated by Beaton and Chery [50], respectively. Our 45–56% estimate for the intersubject CV for nondiscretionary sources, using daily Na intake, is consistent with the value of 56.7% calculated from Nationwide Food Consumption Survey (NFCS) data [7]. The high intersubject CV found for $NaCl_{tab}$ is similar to that noted by Kumanyika and Jones in a study of $NaCl_{tab}$ use by men and women on fixed diets [13]. They report data where the intersubject CV ranged from 89.1 to 120.2%. As in the present study, they also found a low intrasubject/intersubject CV ratio.

With regard to total Na intake, as estimated by diet records, our intrasubject CV of 19.5% is similar to the mean value of 17% observed by Sowers and Stumbo [15], with subjects consuming a diet of comparable Na content to that of our sample. Beaton and Chery have reported an interpolated value of 29.3% using urinary Na excretion data [50]. One study has reported an intersubject CV for Na intake among $NaCl_{tab}$ and $NaCl_{cook}$ users of 39.5% [49], consistent with our 39.3% value. Beaton and Chery imputed an intersubject CV of 17.5% from urinary excretion data [50].

Overall, the high level of variance associated with food record estimates of Na intake hinders efforts to characterize both individuals and groups using this measure. If it is assumed that the variance is primarily attributable to the data collection procedure (rather than actual behavior), our data indicate that 81 days of food records would be required to estimate an individual's true mean intake within 10% of the observed mean. Others have calculated similar figures [51]. This holds important implications for the design and interpretation of studies on Na intake, as well as formulation of public health policy. Collection of 7 days of intake data via diet records is often considered the maximum feasible, yet this time frame yields estimates of individual intake which are practically useless. The observed 95th percentile confidence intervals based upon 7-day means were 1540 to 5478 mg/24 hr. This corresponds to a range of NaCl intake of 3.8–13.7 g/24 hr. This encompasses practically the entire intake range reported for the general population [37]. Thus, it would not be possible from this data to determine, with a reasonable level of confidence, whether most individuals were even above or below the estimated safe and adequate level identified in the 1980 Recommended Dietary Allowances. Our data indicate that five 7-day collection periods are required to reduce the 95% confidence intervals to less than 10%.

The association of total Na intake with discretionary sources, which some feel may be more easily measured, has been examined as a way to circumvent the need for a comprehensive dietary assessment. Unfortunately, a significant association between $NaCl_{tab}$ and total Na intake has not been identified in either our present or past studies [52], nor in work by others [53]. This study indicates that $NaCl_{cook}$ use is also poorly related to total intake.

Discrepancies between certain findings and widespread beliefs about Na intake warrant a comment on the validity and reliability of the present data. First, concerning the external validity of our findings, it must be emphasized that study subjects do not represent a random sample of the US population. The sample is comprised of black and white individuals covering a large segment of the adult age span, with Na intakes comparable to those determined (via 3-day diet records) in the population by the NHANES II study [54]. They represent, how-

ever, only the minority, perhaps 30–50% of the population who regularly use $NaCl_{tab}$ and/or $NaCl_{cook}$ [16]. As such, they may be a segment of the population with somewhat higher total Na intake [49], but lower proportional intake from food-borne Na. The validity of estimated total and discretionary sources is supported by the significant correlations between the total dietary Na and urinary Na excretion values ($r = 0.31$) and by the measured use of NaCl from the table shaker and urinary lithium levels ($r = 0.62$).

The failure to note significant differences in intake levels of any source over time indicates that the estimates are reliable. This study had 85% power to detect a within-subject variance attributable to the passage of time equal to a 20% change in energy intake at the 5% level of probability. Moreover, significant correlations were observed between the first and last test sessions for all sources except Na inherent in foods. This indicates that the relative rankings of subjects on the intake measures were also stable.

Recent findings from the INTERSALT study [55] show an intra- and interpopulation association between Na intake and blood pressure. The data suggest a substantial reduction in morbidity and mortality may be realized in the population by a modest reduction in Na intake. These findings provide a new impetus to act aggressively upon recommendations that Na be moderated in the US population. Although the present findings are not definitive alone, coupled with other accumulating data on NaCl use, they hold important implications for the implementation of these recommendations. It is now apparent that $NaCl_{tab}$ and $NaCl_{cook}$ are small contributors to total intake. Thus, proscriptions against their use will have little impact on total intake. Rather, effective moderation of Na intake will require a different emphasis in the educational and counseling approach than that commonly imparted, one where stronger efforts are directed at influencing food selection rather than preparation. Greater cooperation from the food industry in the form of expanded food labeling and increased availability of reduced Na products will be a crucial adjunct to these educational efforts. Overall, the present challenge may be more difficult than that encountered when attempting to moderate discretionary sources, but several efforts involving intensive counseling have achieved substantial long-term reductions in Na intake [56–58]. One element which seems critical for success is rapid and reliable feedback on dietary adherence [59]. The present data indicate that collection of dietary data may be of little value in this regard. Although less convenient, urinary Na excretion may be a better counseling tool.

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