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Global, regional, and national sodium intakes in 1990 and 2010: a systematic analysis of 24-hour urinary sodium excretion and dietary surveys worldwide

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Global, regional, and national sodium intakes in 1990 and 2010: a systematic analysis of 24-hour urinary sodium excretion and dietary surveys worldwide

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ABSTRACT (300 words)

Objectives

To estimate global, regional (21 regions) and national (187 countries) sodium intakes in adults in 1990 and 2010.

Design

Bayesian hierarchical modeling using all identifiable primary sources.

Data sources and eligibility

We searched and obtained published and unpublished data from 142 surveys of 24-hour urinary sodium and 103 of dietary sodium conducted between 1980 and 2010 across 66 countries. Dietary estimates were converted to urine equivalents based on 79 pairs of dual measurements.

Modeling methods

Bayesian hierarchical modeling incorporated representativeness of survey samples, extent of missing data and comparability of measurements to estimate mean sodium intake, by sex, 5y age group, and year, and associated uncertainty for persons aged 20+ in 187 countries in 1990 and 2010. Country-level covariates were national income per person and indices of types of food available.

Main outcome measures

Mean sodium intake (g/d) as estimable by 24h urine collections, without adjustment for non-urinary losses.

Results

In 2010, global mean sodium intake was 3·95 g/d (95% uncertainty interval: 3·89-4·01), equivalent to 10·06 (9·88-10·21) g/d of salt. Intake in men was ~10% higher than in women; differences by age were small. Intakes were highest in East Asia, Central Asia, and Eastern Europe (mean >4·2 g/d), and in Central Europe and Middle East/North Africa (3·9 to 4·2 g/d). Regional mean intakes in North America, Western Europe, and Australia/New Zealand ranged from 3·4 to 3·8 g/d. Intakes were lower (<3·3 g/d), but more uncertain, in Sub-Saharan Africa and Latin America. Between 1990 and 2010, modest, but somewhat uncertain, increases in sodium intakes were identified.

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Conclusion

Sodium intakes greatly exceed recommended levels in almost all countries worldwide with small differences by age and sex. Virtually all populations would benefit from sodium reduction, supported by enhanced surveillance.

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Article Summary

Article Focus

1. Because excess sodium intakes raise blood pressure, the leading global risk factor for cardiovascular diseases, knowledge of intake levels provides an important foundation for measures to reduce non-communicable diseases globally.
2. We used Bayesian hierarchical modeling with data from 245 surveys to estimate sodium intakes in adults in 187 countries.

Key messages

1. Mean intake of sodium, globally, was ~4g/d, equivalent to ~10 g/d of salt with modest variation by age and sex.
2. Intakes varied 2½ fold across 21 global regions, being highest in East and Central Asia and Eastern Europe and lowest in sub-Saharan Africa and Latin America.
3. Virtually all countries would benefit from reduced sodium intakes, supported by enhanced surveillance.

Strengths and limitations of the study

Strengths

1. This is the first study to produce comprehensive and comparable estimates of sodium intake, and their uncertainties, globally.
2. We identified and made use of a much larger set of primary data sources than previous collations.

Weaknesses

1. In the absence of an established convention for measuring and reporting sodium intakes we have used 24hr urinary excretion, uncorrected for non-renal losses, as a proxy measure. Variation in non-renal (sweat) losses associated with climate or activity levels could introduce additional biases.
2. Use of biochemical markers to assess and control completeness of urine collections was uncommon impeding adjustment for likely downward biases.
3. 24h urine collections mostly came from small surveys that were not based on national probability sampling with consequent sampling bias.
4. Primary data was deficient for much of the global population.

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Introduction

Excess sodium intake raises blood pressure (BP),[1 2] a major risk factor for cardiovascular disease,[3 4] and increases risk of gastric cancer,[5 6] a leading fatal cancer globally.[7] Based on established risks across the current range of population intake levels, major international and national agencies have prioritized sodium reduction to decrease the burdens of non-communicable disease.[8–11] Such efforts have been limited, at least in part, by absence of reliable and comparable data on sodium intake for most countries.[12] This has made it difficult to quantify global, regional, or national levels of dietary sodium and the corresponding preventable disease burdens. Changes in national, regional, and global sodium intakes over time are also not well established.

We therefore systematically reviewed and accessed published and unpublished country-specific surveys of sodium intakes from around the world as part of the 2010 Global Burden of Diseases, Injuries, and Risk Factors (GBD) Study. We developed quantitative methods to produce comparable global, regional, and country-specific estimates of sodium intake, by age and sex subgroups, in 1990 and 2010.

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Methods

Study design

We estimated mean sodium intake and its uncertainty by age and sex for 187 countries in 1990 and 2010. Our strategy included 3 steps: (1) systematic searches for data sources from around the world on individual-level sodium intake, including by age and sex subgroups; (2) retrieval of data, including assessment of data quality, representativeness, missingness, and uncertainty, and quantification of measurement comparability across different survey methods; and (3) application of a hierarchical Bayesian imputation model to incorporate missingness, comparability, and sampling and modeling uncertainty to estimate sodium intake by age, sex, country, and time worldwide.

Identification of surveys, access, and extraction

Between Oct 2008 and Nov 2011, we performed systematic searches to identify both urine-based and diet-based surveys (**Figure 1**). The overall search strategy and results have been described.[13 14] Sources for diet-based measurements were primarily national surveys that had incorporated sampling weights, as appropriate. For countries with no national dietary surveys identified, other potential sources were considered, including subnational surveys, household budget survey data, baseline measurements in large cohort studies, the WHO InfoBase, and the STEP database, published government reports, published sources not previously identified and unpublished data. These searches were complemented by extensive direct contacts with local experts and requests for detailed data.

For urine-based assessments, we searched MEDLINE using the following terms:
((World regions (Mesh)) OR (Name of countries)) AND (salt OR sodium OR Na) AND (intake OR ingest* OR eat* OR consum* OR diet* OR urin* OR excret*)
Limits:Humans, All Adult: 19+ years, Publication Date from 1980/1/1

We also searched for national dietary survey reports and manually searched the reference lists of retrieved articles. We searched publications and web pages of organizations engaged in sodium reduction at national (e.g. UK Food Standards Agency), regional (e.g. European salt reduction program), and international levels (e.g. World Action on Salt and Health) and contacted the nutritional departments of WHO regional offices. Where duplicate sources were

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identified we retained the report with most detail and with most information on the primary metric.

Surveys could be included if they were performed after 1980 and were from a sample that was representative of a national (or if no national survey, a subnational) population; if assessment methods included 24-hour urinary excretion measurements, a diet assessment tool (e.g., diet record, diet recall, food frequency questionnaire [FFQ]), or both; and if there was no evidence suggestive of major selection bias. For example, we excluded studies based exclusively on individuals with hypertension or on pregnant women. Surveys conducted at different locations within a country were counted as different surveys unless they were part of a formal multi-stage sampling design intended to characterize a larger (regional or national) population.

In sum, we identified 142 urine-based surveys and 103 diet-based surveys – with 26 of each forming paired surveys of the same population (**Figure 1 and Table 1**).

Data retrieval and standardization

Because published exposure data were often limited or not in the required format, we obtained data by direct contacts with government officials, scientists, and survey report authors from across the world, who joined our group as Corresponding Members (see list of contributors and **Supplementary Table**). These individuals provided us with either raw data or standardized analyses using an electronic form.[13] Survey characteristics were extracted including date of fieldwork, sampling methods, proportion participating, representativeness, population characteristics, number of subjects by age and sex strata, types and number of measurements (urine, diet including type of dietary tool), validation methods, energy adjustment (for diet-based data), and mean and SD of sodium intake by age and sex groups. To reduce measurement error in dietary estimates by accounting for tendencies to under- or over-report intakes of all foods,[15] dietary data were energy-standardized to 2,000 kilocalories/d (8.37MJ/d). Urinary data were not standardized to energy.

Due to known larger measurement errors in diet-based methods,[16–18] we chose 24-h urinary excretion as our primary metric, and dietary estimates as our secondary metric. We estimated the quantitative relationship between urine and dietary measurements using 79 datapoints from 26 surveys having data on the same individuals in both metrics, and used these results to estimate urinary excretions corresponding to the dietary values in the remaining dietary

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surveys (**Figure 2**). Consequently, our final estimates represent sodium 'intake' using 24-hour urine collections as the reference. We elected not to adjust these final estimates for non-urinary losses (e.g., sweat) because urinary excretion accounts, on average, for ~90% of dietary intake[19–21] and also to enhance comparability with prior estimates of sodium intake (mostly reported as unadjusted 24-h urinary sodium excretion). We also did not attempt to adjust these estimates for potential incomplete collections, which are common even in research settings.[22] Thus, our final estimates of dietary intake can be considered conservative estimates of true sodium consumption.

Bayesian hierarchical imputation

To account for differences in missingness, representativeness, and measurement methods and to incorporate and quantify uncertainty, we developed a Bayesian hierarchical imputation model to estimate mean sodium intake across the world by sex, age, time, and country. Data from country-specific age and sex subgroups were used simultaneously as inputs, with country, regional, and global random effects. This structure allowed the model to borrow information across countries and regions as necessary, while accounting for and quantifying the resulting statistical uncertainties. Representativeness (national with or without probability sampling, subnational) was included as a survey-level covariate. Time-varying country-level covariates further informed the estimates, including lag-distributed national per capita income (inflation and purchasing power parity adjusted[23]) and national dietary patterns characterized by scores on 4 factor variables from an analysis of FAO food balance sheets. Because sodium intakes may be non-linearly associated with age, data on age were incorporated using a cubic spline model.

We fitted the Bayesian model with the Markov chain Monte Carlo (MCMC) algorithm and ran 1000 iterations. Posterior distributions of mean sodium intake for each country by age and sex subgroups were obtained, incorporating and reflecting the above sources of uncertainty. Ninety-five percent uncertainty intervals were obtained from the 2.5th and 97.5th percentiles of the posterior distributions.

Intakes were estimated from the model for 5-year age intervals, by country, sex, and time period, for adults aged 20 years or more. Regional estimates were calculated as population-weighted averages of the constituent country estimates. Intakes for each country, region and time period are reported, both actual intakes (potentially of greater relevance to assessing

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contributions to local disease burdens) and age standardized intakes[24] (for comparing levels across populations and over time).

Further details on the modeling process and its outputs are provided in the **Methods supplement**.

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Results

Data sources

We identified and obtained data from 245 surveys, including 142 reporting 24-hr urinary sodium data and 103 reporting dietary sodium data, with 26 of each forming urine/diet survey pairs. These surveys were conducted in 66 countries comprising 74% of the global adult population. Sixty one percent (149) of the surveys were conducted in high-income regions and 40% (96) in low- and mid-income regions (**Table 1**). East Asia (23 surveys) was the only low- or mid- income region with more than 10 surveys. In sum, the identified surveys provided 1,346 age and sex specific datapoints (mean: 5.5 per survey), of which 651 were urine-based and 695 were diet-based. More than half (376/651) of the urine-based datapoints came from the Intersalt Study, a major international study with standardized protocols conducted between 1985 and 1987.[25] Fifty datapoints, all in European regions, were from collections biochemically validated for completeness using para-amino benzoic acid (PABA).[26] Ten countries had at least 20 urine-based datapoints, including the USA (86), UK (86), Japan (48), China (41), Italy (33), Belgium (24), Finland (24), Germany (24), New Zealand (22) and Netherlands (20). Urine-based data was relatively scarce in the highest age groups, with only 2 urine-based datapoints for age groups 70+ y; in contrast, 97 diet-based datapoints were available at these older ages.

Global and regional sodium intakes

In 2010 global, mean (95% uncertainty interval) sodium intake in adults was 3.95 (3.89-4.01) g/d, equivalent to salt intakes of 10.06 (9.88-10.21) g/d (based on the assumption, conventional in this context, that all the sodium comes from salt). Globally, mean intake in men was about 10% higher than that in women: 4.14 (4.04-4.23) versus 3.77 (3.69 – 3.85) g/d, respectively. In every region, sodium intake was lower in women, ranging from 8.9% lower in South Asia to 10.7% lower in Western Europe. Given these consistent, modest differences, additional findings are presented for both sexes combined.

Interestingly, we also identified relatively little variation in sodium intakes by age. Globally, mean intakes rose by ~6% from age 25-29 (3.78 g/d) to age 40-44 (4.04 g/d), and then remained relatively constant thereafter. This pattern was broadly consistent across each of the 21 GBD Study regions (**Figure 3)**.

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In contrast to small within-region differences by age or sex, marked differences in intake were identified across regions (**Figures 4 and 5**). Asian regions had highest intakes – East Asia (mean, 95% UI) 4.80 (4.59-5.02) g/d, Asia Pacific High Income (mainly Japan and South Korea) 5.00 (4.85-5.16) g/d, and Central Asia 5.51 (5.11-5.95) g/d – corresponding to daily salt intakes of 12.21, 12.71 and 14.01 g, respectively. Very high intakes were also seen in Eastern Europe (4.18 (3.95-4.41) g/d, Central Europe (3.92 (3.73-4.12) g/d, and the Middle East and North Africa (3.92 (3.74-4.12) g/d. Among high-income Western regions, sodium consumption was 3.44 (3.32-3.55) g/d in Australia/New Zealand, 3.62 (3.52-3.72) g/d in the USA/Canada, and 3.81 (3.72-3.91) g/d in Western Europe - equivalent to salt intakes of 8.75, 9.21 and 9.69 g/d, respectively.

Sub-Saharan Africa, Latin America, and the Caribbean and Oceania tended to have lower estimated intakes, but also were based on fewest data sources among all the regions, with resulting larger uncertainties. For example, estimated intakes in Sub-Saharan Africa ranged from 2.18 (2.05-2.32) g/d in Eastern Sub-Saharan Africa to 2.76 (2.58-2.95) g/d in Western Sub-Saharan Africa; and estimated intake in Oceania was 2.48 (2.18–2.80) g/d. Mean intakes were similar or higher in Latin America and the Caribbean, including 2.61 (2.40– 2.83) g/d in the Caribbean, and 3.19 (3.03-3.34) g/d in Central Latin America. Intake in Tropical Latin America (mainly Brazil) was higher than in other Latin American regions and, at 4.11 (4.01–4.22) g/d, exceeded that for US/Canada.

National sodium intakes

We identified substantial variation in estimated sodium intakes across nations (**Figure 6(a), Table 2**). The statistical uncertainty around the estimated intakes for individual countries (**Figure 6(b)**) was larger than that for world regions, especially for countries with no primary data. Thus, relative rankings across different nations should be interpreted in the light of their relative uncertainty levels.

In Western Europe, a region with relatively low uncertainty, estimated mean intakes ranged from 3.28 (2.99-3.59) g/d (Denmark) to 4.43 (4.23-4.62) g/d (Italy). Estimated intakes in the Netherlands, Belgium, Germany and Iceland ranged from 3.33 to 3.59 g/d; in another 12 Western European countries, from 3.62 (3.41-3.86) g/d (Switzerland) to 4.03 (3.78-4.27) g/d (Spain) g/d; and in Cyprus, Luxemburg, Malta, Portugal and Italy, from 4.06 to 4.43 g/d.

Estimated intakes within North Africa/Middle East were also diverse, ranging from 3.13 (2.77–5.54) g/d in Lebanon to 5.37 (4.85-5.92) g/d in Bahrain. In eastern Sub-Saharan Africa,

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estimated consumption was higher in Mauritius (5.45 [4.57-6.50] g/d) than in other neighboring countries (mean intakes ranging from 1.47 to 4.32 g/d).

In other regions, less variation in sodium intake was identified. For example, sodium consumption was very similar in the USA (3.61 (3.51-3.71) g/d) vs. Canada (3.72 (3.59 – 3.84) g/d). Additionally, relatively small within-region differences were observed in Australia/New Zealand, Eastern Europe, South Asia, and each of the regions of Latin America.

Overall in 2010, estimated mean intakes in 181 of 187 countries, representing 99.2% of the world's adult population, exceeded the WHO recommendation of 2.00 g/d sodium (~5 g/d salt).[27] In 119 countries (88.3% of the world's population), estimated intakes exceeding this recommended amount by at least 1 g/d; and in 51 countries (44.8% of the world's adult population), estimated intakes were more than double this recommended amount.

Changes over time

Globally between 1990 and 2010, modest, statistically non-significant global increases were seen, from 4.02 (3.93-4.11) to 4.14 (4.04-4.23) g/d in males and from 3.63 (3.55–3.71) to 3.77 (3.69–3.85) g/d in females. By region, estimated increases were larger for East Asia, from 4.37 (4.18-4.58) to 4.80 (4.59-5.02) g/d; and Eastern Europe, from 3.76 (3.55-3.97) to 4.18 (3.95-4.41) g/d (for both sexes combined). These estimated increases appeared sensitive to the large proportion of urine-based data in earlier years that was collected in Intersalt (1985-87). When only diet-based data were evaluated, the direction of secular change tended to reverse (data not shown). Thus, estimates of trends over time should be interpreted cautiously. Figure 5 and Table 2 show changes in age-standardised estimates for regions and countries respectively.

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Discussion

Our findings provide systematically assessed and comprehensive evidence on global, regional, and national intake levels and patterns of sodium consumption, including by age and sex. Several findings are notable. Within regions and countries, only small differences were evident comparing younger to older adults or men to women. This suggests relatively constant and common exposures to sodium within populations. On the other hand, marked differences were evident between regions and between countries. Interestingly, these differences were not strongly related to national income, suggesting that in contrast to many other dietary components that are linked to national wealth or affluence, sodium intake is more strongly influenced by other factors. For example, the geographic distribution of highest intakes from East Asia to Eastern and Central Europe suggests a "Silk Road" pattern, implying shared retentions from past transportation and food cultures such as use of salt for food preservation.[28]

A recent Institute of Medicine committee concluded that, based only on studies of clinical events, evidence was insufficient to conclusively choose between modest (e.g., 2.3 g/d) vs. low (e.g., 1.5 g/d) sodium intakes as long term targets for populations.[29] The resulting controversy over this relatively narrow statement overshadowed their other main conclusion that, considered collectively, the evidence indicated a positive relationship between high sodium intakes and cardiovascular events and was consistent with BP-raising effects of dietary sodium. Numerous other organizations have systematically reviewed the evidence and concluded that high intakes of sodium increase cardiovascular risk.[11 27 30] Thus, whereas identified optimal target intakes have varied from 1.20 to 2.4 g/d,[27 30 31] all have consistently concluded that sodium intakes above these levels are adverse for health. Our findings demonstrate that, whether for modest (2 to 2.4 g/d) or low (1.20 to 1.5 g/d) target intakes, virtually every nation in the world, and each age and sex group within these nations, exceeds optimal intakes.

Reporting first in 1988, the Intersalt study provided the first extensive body of comparable urine based data on sodium consumption globally, with results from 52 surveys in 30 countries.[32] In 2009, Brown and colleagues produced a tabular update of

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11 diet-based and 26 urine-based surveys published after Intersalt.[12] We are not aware of any previous reports that have imputed national sodium intake levels globally.

Strengths and innovations of our investigation can be highlighted. We systematically identified and extracted data from around the world on both urinary and dietary sodium, including many sources of previously unavailable data. We evaluated and incorporated the evidence for systematic differences between urinary and dietary estimates, increasing comparability and allowing us to draw on the different strengths of each. Our analytic methods took advantage of all available data but gave precedence to urinary over dietary estimates and to nationally representative over subnational studies, increasing both coverage and validity.

Potential limitations should be considered. Primary data sources were limited or missing in many countries. Our model dealt with this by 'borrowing' information within and across countries, regions, and time, based on both country-level and survey-level covariates; it also incorporated both missingness and types of available data to quantify the final uncertainty. In contrast with diet based surveys many of which were based on national probability samples, urine-based surveys were often of smaller size and representative only of local populations. We had more limited data across time to quantify temporal trends in intakes. In addition, our analysis evaluated intakes in 1990 and 2010, which does not exclude larger changes over a broader time horizon. For instance, reported intakes in Japan[33] Portugal[34] and Finland[35] from several decades ago were much higher than our recent estimates. This implies potentially large reductions in sodium intakes in these countries over time frames longer than covered in our study, consistent with changes in traditional methods of food preservation made possible by widespread refrigeration.[36] Conversely, more recent increased global consumption of highly processed foods [37] may be countering or even reversing these historical associations between modernization and declining sodium intakes.

In May 2013, the 66th World Health Assembly followed up the 2011 United Nations High-Level Summit on the Prevention and Control of Non-Communicable Diseases with a resolution endorsing a global action plan that included a proposed 30% reduction in salt/sodium intake.[38] Our findings can help inform the planning and design of such high priority programs. Optimal strategies for reducing sodium will partly depend on the proportion of dietary sodium derived from cooking or table salt

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(e.g., relatively high in Asian nations) vs. from preprepared or industrialized foods (e.g., the majority in high-income Western nations).[12] In a limited number of high-income countries, sustained, coordinated public health programs have helped lower sodium intakes, for example in Japan,[39] Finland[35] and the UK[40]. The most recent surveillance data from the UK (too late for inclusion in our model) documents a 15% reduction in mean sodium intakes over the preceding decade, coinciding with a coordinated national program which includes formal food industry commitments.[41] Media and educational programs can also have an impact in countries where substantial proportions of dietary sodium are added during household food preparation and at the table.[42] Simulations suggest that population-wide sodium reduction strategies would be not only cost-effective, but could be cost-saving.[43–45] While the food industry often cites taste as a major barrier to sodium reduction, our findings provide empiric evidence on the remarkable adaptability of the human palate to preference for salt,[46] with usual sodium intakes varying more than 2.5-fold across world regions and 4-fold across nations.

Our results also highlight data gaps and the need for improved surveillance of sodium intakes using transparent, validated and comparable methods. To our knowledge, only the UK has an optimal surveillance system, i.e. one that includes serial surveys of national probability samples using urine collections that are biochemically validated for completeness.[22 41] Yet, our findings on mean levels across and within countries indicate that, for virtually all countries, it is likely to be some time before mean intakes approach levels at which the benefits of further reduction may be uncertain.[29] Thus, the remaining uncertainties highlighted by our work inform the need for further research but do not alter the imperative for strong, active public health policies to reduce national sodium intakes from their current levels.

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Contributorship statement

Summary version

ME, JP and DM conceived and designed the study. DM obtained funding. SF, RM, SK and PS designed and carried out the data collection, extraction and coding. SSL and REE designed and carried out the statistical modelling with help from all coauthors. JP and DM drafted the paper which was critically reviewed by all other coauthors. JP and DM had full access to all the data, take full responsibility for its integrity and are guarantors for the paper.

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John Powles: Study concept and design; data collection; data analysis; interpretation of data; drafting of the manuscript; critical revision of the manuscript for important intellectual content.

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FIGURE LEGENDS

Figure 1. Search strategies for global sodium exposure data: urine-based (left) and diet-based (right)

[Footnote] The black dashed lines show dietary Na assessment studies that were identified through the search for 24-hour urinary sodium excretion studies.

Figure 2. Relationship between measured urinary sodium and measured dietary sodium in 79 age/sex strata from 26 survey pairs

[Footnote] The solid line represents the cross-walk regression line (linear regression of log-transformed dietary versus log-transformed urinary sodium); and the dotted lines, the 95% uncertainty intervals. With the exception of 8 age and sex strata, very good agreement was seen between the two metrics. The regression co-efficient obtained from this analysis was used to inform the Bayesian hierarchical imputation model of the relationship between the two metrics.

Figure 3. Sodium intakes in g/d by age, for regions and globally, both sexes combined, 2010

Figure 4. Mean (95% uncertainty interval) sodium intakes (g/d) in 2010 in 21 GBD regions

[Footnote] Regions are ranked by levels in both sexes combined, ages 20+. Intakes are not age-standardised.

Figure 5. Mean (95% uncertainty interval) age-standardised sodium intakes (g/d) in 1990 and 2010 in 21 GBD regions

[Footnote] The upper symbol for each pair is for 2010. Regions are ranked by levels in both sexes combined, ages 20+.

Figure 6. Sodium intakes by country, for ages 20+, average of both sexes, in 2010. Panel (a) presents mean intakes in g/d; panel (b) presents relative uncertainty*

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[Foonote] *Monte Carlo standard errors divided by the mean of these intake estimates.

Supplementary Materials

Methods Supplement: The imputation model: Dismod III

With associated figures

Figure S1. Guide to model outputs for regions

Figure S2. Model output for regions (1)

Figure S3. Model output for regions (2)

Figure S4. Model output for regions (3)

Figure S5. Model output for regions (4)

Supplementary Table. Surveys and survey pairs used in the assessment of sodium exposure with identification of sources for published reports and of corresponding members where data was provided on request.

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Table 1. Classification of 245 surveys of sodium intake by exposure metric reported, period of survey and national representativeness, with pairs of surveys reporting in both metrics identified.

	Surveys (n=245)		Survey characteristics (n=219 counting survey pairs as 1)						
			Contributing surveys and survey pairs by metric				Period		
GBD Region (*=high income)	Urine-based	Diet-based	Urine-based only	Diet-based only	Both (survey pairs)†	Total	1980-1998	1999-2010	Nationally represent-ative
Asia, Central	1	0	1	0	0	1	1	0	1 (100%)
Asia, East	11	15	8	12	3	23	21	2	3 (13%)
Asia Pacific High Income*	12	11	7	5	6	18	14	4	4 (22%)
Asia, South	2	4	2	4	0	6	3	3	0 (0%)
Asia, Southeast	2	3	2	3	0	5	2	3	2 (40%)
Australasia*	8	1	8	1	0	9	6	3	1 (11%)
Caribbean	5	2	5	2	0	7	6	1	2 (29%)
Europe, Central	4	2	4	2	0	6	2	4	3 (50%)
Europe, Eastern	1	1	1	1	0	2	2	0	1 (50%)
Europe, Western*	51	31	46	27	4	77	45	32	27 (35%)
Latin America, Andean	0	0	0	0	0	0	0	0	NA
Latin America, Central	3	1	3	1	0	4	3	1	1 (25%)
Latin America, Southern	1	1	1	1	0	2	1	1	1 (50%)
Latin America, Tropical	0	2	0	2	0	2	0	2	1 (50%)
North America, High Income*	21	14	11	4	10	25	20	5	4 (16%)
North Africa Middle East	2	7	2	7	0	9	2	7	4 (44%)
Oceania	1	2	1	2	0	3	3	0	3 (100%)
Sub-Saharan Africa, East	3	2	3	2	0	5	5	0	0 (0%)
Sub-Saharan Africa, Central	0	0	0	0	0	0	0	0	NA
Sub-Saharan Africa, Southern	7	4	4	1	3	8	4	4	1 (13%)
Sub-Saharan Africa, West	7	0	7	0	0	7	5	2	0 (0%)
Total	142	103	116	77	26†	219	145	74	55 (35%‡)

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† These 26 surveys with measurements in both metrics reported on all subjects provided the 79 paired urine-diet datapoints that were used to estimate the relationship between the 2 metrics (Figure 2); the diet-based datapoints from these 26 surveys were not subsequently used in the final imputation model.

‡ Unweighted mean for 19 regions with at least 1 survey

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Table 2. Age-standardised estimated sodium intakes (g/d) in 1990 and 2010, persons aged 20 and over, by country (95% uncertainty intervals).

	Total		Males		Females	
	1990	2010	1990	2010	1990	2010
Afghanistan	3.29 (2.71-3.95)	3.39 (2.79-4.06)	3.44 (2.61-4.46)	3.55 (2.63-4.69)	3.12 (2.36-4.06)	3.22 (2.42-4.17)
Albania	3.47 (2.89-4.16)	3.67 (3.05-4.34)	3.64 (2.83-4.62)	3.86 (2.98-5.00)	3.31 (2.56-4.29)	3.48 (2.67-4.37)
Algeria	3.91 (3.32-4.59)	4.28 (3.59-5.00)	4.09 (3.19-5.17)	4.51 (3.50-5.72)	3.73 (2.97-4.74)	4.07 (3.20-5.08)
Andorra	3.56 (3.04-4.16)	3.81 (3.21-4.44)	3.85 (3.05-4.83)	4.01 (3.19-5.07)	3.29 (2.59-4.05)	3.61 (2.84-4.53)
Angola	2.46 (2.07-2.90)	2.49 (2.06-2.97)	2.58 (2.03-3.28)	2.61 (2.02-3.35)	2.35 (1.82-2.94)	2.38 (1.86-3.07)
Antigua and Barbuda	2.71 (2.28-3.23)	2.67 (2.23-3.18)	2.85 (2.19-3.64)	2.81 (2.18-3.55)	2.58 (2.01-3.26)	2.54 (1.98-3.24)
Argentina	3.01 (2.93-3.10)	3.00 (2.92-3.08)	3.16 (3.03-3.29)	3.15 (3.03-3.26)	2.87 (2.76-2.99)	2.87 (2.76-2.98)
Armenia	4.84 (4.04-5.67)	4.92 (4.13-5.77)	5.07 (4.03-6.31)	5.19 (4.06-6.57)	4.65 (3.64-5.86)	4.71 (3.69-5.89)
Australia	3.38 (3.26-3.50)	3.42 (3.29-3.55)	3.55 (3.37-3.75)	3.59 (3.39-3.77)	3.22 (3.05-3.40)	3.26 (3.09-3.42)
Austria	3.89 (3.57-4.22)	3.95 (3.63-4.31)	4.20 (3.73-4.73)	4.16 (3.70-4.64)	3.60 (3.22-4.06)	3.76 (3.29-4.28)
Azerbaijan	4.55 (3.83-5.34)	5.06 (4.31-5.98)	4.79 (3.74-6.08)	5.31 (4.18-6.71)	4.35 (3.44-5.56)	4.85 (3.83-6.13)
Bahamas	3.03 (2.53-3.60)	2.99 (2.48-3.54)	3.18 (2.41-4.10)	3.13 (2.41-3.97)	2.89 (2.24-3.65)	2.86 (2.22-3.67)
Bahrain	4.40 (4.03-4.82)	5.38 (4.85-5.91)	4.56 (4.05-5.11)	5.57 (4.88-6.31)	4.15 (3.68-4.69)	5.05 (4.42-5.72)
Bangladesh	3.68 (3.09-4.41)	3.54 (2.98-4.21)	3.84 (3.02-4.93)	3.71 (2.89-4.67)	3.51 (2.76-4.41)	3.38 (2.63-4.32)
Barbados	3.40 (3.12-3.69)	3.42 (3.11-3.76)	3.56 (3.17-3.99)	3.59 (3.12-4.09)	3.25 (2.87-3.65)	3.25 (2.85-3.69)
Belarus	4.00 (3.39-4.72)	4.35 (3.69-5.16)	4.19 (3.28-5.22)	4.55 (3.55-5.69)	3.83 (2.98-4.72)	4.17 (3.27-5.24)
Belgium	3.48 (3.30-3.67)	3.45 (3.23-3.68)	3.76 (3.48-4.05)	3.64 (3.32-3.96)	3.21 (2.98-3.46)	3.27 (2.98-3.60)
Belize	2.67 (2.38-3.02)	2.62 (2.34-2.93)	2.80 (2.38-3.29)	2.75 (2.31-3.21)	2.55 (2.17-3.01)	2.50 (2.10-2.93)
Benin	2.86 (2.53-3.28)	2.85 (2.49-3.22)	3.01 (2.50-3.57)	2.97 (2.47-3.52)	2.73 (2.27-3.26)	2.73 (2.28-3.25)
Bhutan	3.72 (3.13-4.33)	3.64 (3.07-4.24)	3.88 (3.05-4.86)	3.80 (2.97-4.78)	3.55 (2.82-4.46)	3.45 (2.74-4.26)
Bolivia, Plurinational State of	3.51 (2.97-4.11)	3.59 (3.02-4.20)	3.67 (2.90-4.54)	3.77 (3.01-4.69)	3.35 (2.63-4.16)	3.41 (2.71-4.30)
Bosnia and Herzegovina	3.26 (2.71-3.93)	3.46 (2.88-4.15)	3.43 (2.62-4.41)	3.62 (2.78-4.59)	3.10 (2.38-4.07)	3.32 (2.58-4.25)
Botswana	2.49 (2.07-2.95)	2.53 (2.15-2.97)	2.63 (2.05-3.33)	2.66 (2.06-3.30)	2.37 (1.85-2.97)	2.40 (1.90-3.00)
Brazil	3.89 (3.78-3.99)	4.11 (4.01-4.22)	4.08 (3.93-4.23)	4.31 (4.17-4.46)	3.70 (3.57-3.83)	3.92 (3.79-4.07)
Brunei Darussalam	4.40 (3.70-5.13)	4.42 (3.71-5.16)	4.59 (3.62-5.73)	4.62 (3.59-5.83)	4.18 (3.27-5.24)	4.21 (3.27-5.30)
Bulgaria	3.63 (3.40-3.85)	3.62 (3.39-3.87)	3.82 (3.48-4.17)	3.80 (3.45-4.18)	3.45 (3.14-3.78)	3.45 (3.13-3.79)
Burkina Faso	2.91 (2.46-3.46)	2.88 (2.40-3.41)	3.07 (2.41-3.91)	3.04 (2.38-3.80)	2.77 (2.15-3.53)	2.74 (2.11-3.47)
Burundi	1.62 (1.31-1.99)	1.73 (1.42-2.09)	1.70 (1.25-2.26)	1.82 (1.38-2.36)	1.56 (1.14-2.07)	1.65 (1.23-2.15)
Cambodia	4.54 (3.81-5.38)	4.41 (3.73-5.18)	4.76 (3.69-6.07)	4.65 (3.68-5.87)	4.37 (3.41-5.52)	4.20 (3.26-5.24)
Cameroon	2.07 (1.82-2.35)	2.09 (1.84-2.36)	2.18 (1.81-2.59)	2.19 (1.81-2.58)	1.97 (1.64-2.32)	1.99 (1.68-2.38)

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Canada	3.55 (3.45-3.66)	3.71 (3.58-3.83)	3.74 (3.58-3.90)	3.88 (3.69-4.08)	3.37 (3.22-3.52)	3.53 (3.36-3.70)
Cape Verde	2.99 (2.55-3.51)	3.25 (2.74-3.89)	3.16 (2.47-3.92)	3.42 (2.63-4.33)	2.87 (2.21-3.63)	3.10 (2.39-3.86)
Central African Republic	2.75 (2.32-3.25)	2.80 (2.33-3.29)	2.89 (2.24-3.62)	2.94 (2.30-3.71)	2.62 (2.06-3.27)	2.66 (2.05-3.37)
Chad	2.87 (2.42-3.38)	2.87 (2.43-3.37)	3.00 (2.33-3.78)	3.02 (2.37-3.76)	2.74 (2.12-3.38)	2.72 (2.15-3.39)
Chile	2.79 (2.38-3.29)	2.80 (2.35-3.31)	2.92 (2.30-3.74)	2.92 (2.29-3.70)	2.67 (2.11-3.37)	2.69 (2.13-3.36)
China	4.42 (4.24-4.63)	4.83 (4.62-5.05)	4.63 (4.35-4.93)	5.05 (4.71-5.39)	4.20 (3.94-4.49)	4.60 (4.31-4.88)
Colombia	4.12 (3.77-4.45)	4.09 (3.77-4.43)	4.31 (3.82-4.83)	4.29 (3.83-4.81)	3.93 (3.50-4.43)	3.91 (3.48-4.36)
Comoros	1.69 (1.42-2.02)	1.67 (1.41-1.98)	1.78 (1.39-2.26)	1.74 (1.35-2.22)	1.61 (1.22-2.04)	1.59 (1.24-2.03)
Congo	2.30 (1.95-2.70)	2.25 (1.88-2.67)	2.42 (1.89-3.05)	2.35 (1.83-2.97)	2.18 (1.69-2.73)	2.15 (1.63-2.78)
Congo, the Democratic Republic of the	2.27 (1.90-2.66)	2.42 (2.05-2.84)	2.39 (1.84-2.95)	2.54 (1.97-3.24)	2.16 (1.68-2.74)	2.31 (1.82-2.90)
Costa Rica	2.98 (2.51-3.50)	3.18 (2.71-3.73)	3.13 (2.49-3.91)	3.32 (2.56-4.18)	2.83 (2.20-3.56)	3.03 (2.40-3.76)
Côte dIvoire	2.78 (2.48-3.13)	2.80 (2.50-3.13)	2.90 (2.45-3.42)	2.94 (2.48-3.45)	2.64 (2.22-3.11)	2.65 (2.25-3.11)
Croatia	3.25 (2.73-3.81)	3.71 (3.15-4.34)	3.42 (2.70-4.28)	3.88 (3.04-4.80)	3.10 (2.44-3.92)	3.54 (2.80-4.45)
Cuba	2.80 (2.36-3.29)	2.64 (2.23-3.12)	2.94 (2.32-3.67)	2.75 (2.16-3.46)	2.66 (2.07-3.27)	2.52 (1.99-3.21)
Cyprus	3.76 (3.17-4.45)	4.06 (3.41-4.76)	4.05 (3.18-5.12)	4.29 (3.26-5.36)	3.49 (2.71-4.39)	3.83 (3.03-4.81)
Czech Republic	3.74 (3.16-4.44)	3.98 (3.37-4.74)	3.97 (3.14-5.02)	4.17 (3.31-5.31)	3.53 (2.75-4.36)	3.80 (3.00-4.75)
Denmark	3.53 (3.23-3.82)	3.27 (2.98-3.58)	3.80 (3.36-4.29)	3.43 (3.00-3.88)	3.26 (2.87-3.67)	3.11 (2.72-3.55)
Djibouti	2.29 (1.90-2.72)	2.36 (1.94-2.81)	2.39 (1.85-3.07)	2.48 (1.91-3.14)	2.19 (1.67-2.81)	2.24 (1.74-2.84)
Dominica	2.62 (2.21-3.10)	2.69 (2.30-3.20)	2.74 (2.14-3.44)	2.82 (2.13-3.60)	2.51 (1.96-3.22)	2.57 (1.96-3.29)
Dominican Republic	2.45 (2.08-2.85)	2.60 (2.21-3.03)	2.57 (2.01-3.26)	2.70 (2.14-3.38)	2.32 (1.83-2.86)	2.50 (1.99-3.12)
Ecuador	2.88 (2.41-3.38)	3.03 (2.55-3.57)	3.00 (2.37-3.76)	3.17 (2.47-4.01)	2.76 (2.16-3.45)	2.88 (2.29-3.66)
Egypt	3.63 (3.10-4.22)	3.68 (3.13-4.32)	3.81 (3.01-4.75)	3.85 (3.00-4.82)	3.45 (2.75-4.33)	3.52 (2.77-4.36)
El Salvador	3.19 (2.64-3.79)	3.19 (2.71-3.71)	3.35 (2.60-4.28)	3.36 (2.63-4.22)	3.04 (2.37-3.85)	3.05 (2.39-3.81)
Equatorial Guinea	2.50 (2.12-3.00)	2.30 (1.90-2.78)	2.61 (2.07-3.24)	2.40 (1.80-3.08)	2.37 (1.89-3.04)	2.20 (1.67-2.90)
Eritrea	2.32 (1.93-2.73)	2.37 (2.00-2.82)	2.43 (1.88-3.11)	2.50 (1.96-3.18)	2.22 (1.71-2.78)	2.25 (1.76-2.83)
Estonia	3.49 (3.30-3.69)	3.95 (3.69-4.23)	3.67 (3.40-3.96)	4.15 (3.76-4.56)	3.33 (3.07-3.60)	3.77 (3.43-4.16)
Ethiopia	2.30 (1.92-2.70)	2.27 (1.95-2.67)	2.42 (1.87-3.07)	2.38 (1.87-2.97)	2.19 (1.72-2.74)	2.17 (1.72-2.71)
Fiji	2.86 (2.41-3.35)	2.87 (2.41-3.41)	2.99 (2.34-3.76)	3.01 (2.36-3.84)	2.73 (2.16-3.42)	2.74 (2.13-3.43)
Finland	3.73 (3.52-3.95)	3.85 (3.63-4.07)	4.02 (3.70-4.39)	4.05 (3.72-4.40)	3.44 (3.16-3.74)	3.65 (3.35-3.94)
France	3.70 (3.52-3.91)	3.77 (3.58-3.97)	4.00 (3.72-4.30)	3.96 (3.66-4.28)	3.41 (3.17-3.65)	3.58 (3.31-3.86)
Gabon	1.93 (1.58-2.36)	2.01 (1.63-2.45)	2.02 (1.53-2.62)	2.09 (1.55-2.76)	1.83 (1.39-2.35)	1.92 (1.42-2.54)
Gambia	3.04 (2.58-3.61)	3.07 (2.59-3.58)	3.18 (2.51-4.05)	3.22 (2.56-4.06)	2.88 (2.24-3.63)	2.93 (2.27-3.73)
Georgia	4.73 (3.95-5.60)	5.30 (4.49-6.26)	4.95 (3.94-6.29)	5.57 (4.44-7.03)	4.53 (3.55-5.72)	5.07 (3.96-6.29)
Germany	3.45 (3.24-3.68)	3.54 (3.36-3.73)	3.73 (3.42-4.07)	3.72 (3.43-4.02)	3.18 (2.91-3.47)	3.36 (3.13-3.61)
Ghana	2.44 (2.19-2.73)	2.35 (2.09-2.61)	2.56 (2.19-2.98)	2.45 (2.09-2.88)	2.32 (2.02-2.71)	2.24 (1.89-2.62)
Greece	3.55 (2.92-4.25)	3.77 (3.16-4.52)	3.82 (2.92-4.91)	3.97 (3.11-5.03)	3.29 (2.53-4.27)	3.58 (2.76-4.53)

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Grenada	2.44 (2.07-2.85)	2.61 (2.20-3.09)	2.55 (2.02-3.21)	2.73 (2.14-3.48)	2.33 (1.83-2.91)	2.48 (1.92-3.18)
Guatemala	2.86 (2.52-3.22)	2.94 (2.60-3.28)	2.99 (2.50-3.53)	3.08 (2.59-3.63)	2.73 (2.31-3.19)	2.81 (2.38-3.29)
Guinea	2.71 (2.29-3.22)	2.77 (2.33-3.26)	2.84 (2.23-3.58)	2.92 (2.30-3.64)	2.59 (2.04-3.27)	2.62 (2.06-3.25)
Guinea-Bissau	2.94 (2.48-3.48)	3.03 (2.55-3.61)	3.09 (2.44-3.87)	3.17 (2.49-4.09)	2.80 (2.23-3.50)	2.90 (2.25-3.66)
Guyana	2.36 (1.98-2.78)	2.45 (2.05-2.93)	2.47 (1.91-3.14)	2.56 (2.02-3.30)	2.26 (1.78-2.88)	2.34 (1.82-2.98)
Haiti	2.43 (2.02-2.86)	2.66 (2.23-3.15)	2.56 (2.00-3.14)	2.78 (2.17-3.50)	2.31 (1.79-2.94)	2.54 (1.98-3.26)
Honduras	2.88 (2.42-3.41)	2.95 (2.49-3.48)	3.02 (2.40-3.75)	3.07 (2.38-3.88)	2.75 (2.11-3.49)	2.84 (2.24-3.55)
Hungary	4.28 (3.90-4.67)	4.23 (3.87-4.57)	4.50 (3.94-5.13)	4.43 (3.91-4.95)	4.07 (3.57-4.62)	4.04 (3.60-4.50)
Iceland	3.53 (3.15-3.90)	3.58 (3.24-3.97)	3.79 (3.23-4.33)	3.77 (3.22-4.34)	3.25 (2.78-3.78)	3.38 (2.92-3.90)
India	3.78 (3.69-3.87)	3.72 (3.63-3.82)	3.95 (3.82-4.07)	3.88 (3.73-4.02)	3.61 (3.49-3.73)	3.56 (3.44-3.68)
Indonesia	3.43 (3.07-3.82)	3.36 (3.02-3.76)	3.59 (3.09-4.18)	3.53 (3.02-4.09)	3.28 (2.82-3.81)	3.21 (2.77-3.75)
Iran, Islamic Republic of	3.85 (3.46-4.27)	4.02 (3.64-4.44)	4.03 (3.46-4.64)	4.21 (3.65-4.85)	3.67 (3.17-4.20)	3.83 (3.33-4.37)
Iraq	3.46 (2.94-4.09)	3.76 (3.19-4.46)	3.64 (2.86-4.61)	3.95 (3.12-5.00)	3.30 (2.63-4.18)	3.59 (2.85-4.51)
Ireland	3.61 (3.24-4.06)	3.74 (3.35-4.18)	3.91 (3.35-4.57)	3.93 (3.38-4.58)	3.32 (2.84-3.85)	3.55 (3.01-4.14)
Israel	3.68 (3.20-4.17)	3.79 (3.27-4.37)	3.97 (3.21-4.81)	4.00 (3.20-4.91)	3.40 (2.79-4.08)	3.59 (2.91-4.32)
Italy	4.31 (4.11-4.51)	4.42 (4.22-4.61)	4.65 (4.30-4.98)	4.65 (4.34-4.96)	3.99 (3.72-4.26)	4.19 (3.92-4.45)
Jamaica	1.90 (1.76-2.06)	1.92 (1.77-2.08)	2.00 (1.81-2.22)	2.01 (1.79-2.26)	1.82 (1.63-2.03)	1.84 (1.63-2.06)
Japan	4.71 (4.54-4.89)	4.89 (4.71-5.08)	4.93 (4.67-5.19)	5.12 (4.85-5.41)	4.50 (4.27-4.75)	4.68 (4.43-4.93)
Jordan	3.54 (3.00-4.19)	4.13 (3.47-4.87)	3.69 (2.93-4.62)	4.31 (3.41-5.48)	3.38 (2.67-4.19)	3.95 (3.04-5.00)
Kazakhstan	4.92 (4.17-5.74)	5.98 (5.07-7.14)	5.16 (4.07-6.41)	6.31 (4.95-7.98)	4.72 (3.66-5.84)	5.70 (4.47-7.21)
Kenya	1.43 (1.30-1.58)	1.48 (1.34-1.62)	1.50 (1.29-1.71)	1.55 (1.34-1.77)	1.37 (1.19-1.58)	1.41 (1.22-1.60)
Kiribati	2.18 (1.80-2.65)	2.22 (1.82-2.68)	2.27 (1.72-2.97)	2.31 (1.72-3.05)	2.07 (1.59-2.70)	2.14 (1.60-2.79)
Korea, Democratic Peoples Republic of	3.34 (2.75-3.95)	3.79 (3.16-4.46)	3.49 (2.70-4.39)	4.01 (3.07-5.21)	3.20 (2.46-4.03)	3.59 (2.79-4.55)
Korea, Republic of	4.92 (4.68-5.17)	5.21 (4.98-5.48)	5.15 (4.79-5.52)	5.46 (5.12-5.81)	4.70 (4.39-5.04)	4.98 (4.66-5.32)
Kuwait	3.66 (3.31-4.05)	3.88 (3.46-4.31)	3.81 (3.32-4.36)	4.01 (3.45-4.60)	3.46 (3.02-3.95)	3.65 (3.13-4.19)
Kyrgyzstan	5.09 (4.29-5.98)	5.38 (4.55-6.32)	5.34 (4.30-6.64)	5.64 (4.43-7.12)	4.88 (3.79-6.04)	5.14 (4.08-6.41)
Lao Peoples Democratic Republic	4.58 (3.80-5.44)	4.45 (3.75-5.27)	4.78 (3.83-6.02)	4.69 (3.63-5.98)	4.39 (3.43-5.53)	4.23 (3.31-5.36)
Latvia	3.58 (3.03-4.24)	4.19 (3.57-5.01)	3.75 (2.97-4.74)	4.37 (3.41-5.45)	3.43 (2.74-4.30)	4.02 (3.20-5.08)
Lebanon	2.60 (2.34-2.88)	3.13 (2.78-3.54)	2.72 (2.32-3.15)	3.30 (2.75-3.89)	2.50 (2.13-2.91)	2.98 (2.49-3.52)
Lesotho	2.66 (2.18-3.14)	2.62 (2.21-3.11)	2.79 (2.13-3.56)	2.76 (2.16-3.49)	2.55 (1.94-3.23)	2.50 (1.92-3.18)
Liberia	2.64 (2.23-3.14)	2.68 (2.23-3.17)	2.76 (2.12-3.49)	2.82 (2.20-3.60)	2.52 (2.01-3.17)	2.55 (1.96-3.26)
Libyan Arab Jamahiriya	3.74 (3.14-4.45)	4.24 (3.55-5.01)	3.90 (3.06-4.97)	4.45 (3.50-5.60)	3.54 (2.76-4.50)	4.03 (3.15-5.08)
Lithuania	3.60 (3.04-4.27)	4.07 (3.47-4.74)	3.77 (3.00-4.64)	4.27 (3.44-5.38)	3.45 (2.73-4.34)	3.90 (3.06-4.79)
Luxembourg	3.87 (3.29-4.56)	4.07 (3.42-4.82)	4.18 (3.27-5.20)	4.28 (3.36-5.37)	3.57 (2.81-4.60)	3.85 (2.99-4.88)
Macedonia, the former Yugoslav Republic of	3.30 (2.77-3.90)	3.91 (3.31-4.55)	3.48 (2.75-4.47)	4.10 (3.21-5.09)	3.13 (2.47-3.98)	3.72 (2.93-4.64)
Madagascar	2.15 (1.83-2.59)	2.20 (1.85-2.58)	2.25 (1.75-2.86)	2.31 (1.81-2.88)	2.05 (1.61-2.61)	2.09 (1.65-2.65)

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Malawi	1.63 (1.45-1.83)	1.66 (1.47-1.86)	1.71 (1.45-2.00)	1.73 (1.46-2.03)	1.56 (1.32-1.84)	1.58 (1.33-1.86)
Malaysia	3.42 (3.11-3.76)	3.57 (3.25-3.93)	3.57 (3.12-4.07)	3.74 (3.29-4.29)	3.27 (2.86-3.75)	3.40 (2.95-3.87)
Maldives	3.68 (3.00-4.49)	3.31 (2.58-4.17)	3.84 (2.77-5.05)	3.47 (2.37-4.88)	3.50 (2.56-4.65)	3.14 (2.18-4.26)
Mali	3.21 (2.71-3.74)	3.15 (2.67-3.76)	3.38 (2.69-4.28)	3.31 (2.57-4.20)	3.05 (2.38-3.86)	3.01 (2.35-3.80)
Malta	3.88 (3.53-4.25)	4.10 (3.74-4.50)	4.19 (3.66-4.75)	4.31 (3.78-4.89)	3.58 (3.14-4.03)	3.90 (3.44-4.45)
Marshall Islands	2.49 (2.11-2.94)	2.55 (2.15-3.01)	2.60 (2.05-3.31)	2.68 (2.12-3.40)	2.37 (1.87-3.00)	2.43 (1.88-3.05)
Mauritania	3.10 (2.61-3.69)	2.97 (2.49-3.48)	3.25 (2.53-4.15)	3.12 (2.43-3.99)	2.96 (2.32-3.75)	2.84 (2.21-3.57)
Mauritius	5.05 (4.23-5.93)	5.45 (4.57-6.50)	5.28 (4.10-6.65)	5.71 (4.40-7.28)	4.83 (3.77-6.20)	5.20 (4.06-6.60)
Mexico	2.71 (2.54-2.90)	2.76 (2.57-2.94)	2.85 (2.59-3.14)	2.89 (2.62-3.17)	2.58 (2.35-2.85)	2.63 (2.39-2.89)
Micronesia, Federated States of	2.51 (2.11-2.94)	2.56 (2.17-3.03)	2.62 (2.06-3.29)	2.68 (2.12-3.37)	2.39 (1.84-3.00)	2.44 (1.88-3.04)
Moldova, Republic of	3.59 (3.03-4.31)	3.95 (3.32-4.65)	3.80 (3.00-4.81)	4.13 (3.27-5.28)	3.41 (2.72-4.29)	3.79 (2.93-4.79)
Mongolia	5.18 (4.90-5.46)	5.14 (4.84-5.43)	5.43 (5.02-5.86)	5.38 (4.95-5.84)	4.94 (4.60-5.31)	4.91 (4.54-5.33)
Montenegro	3.15 (2.63-3.72)	3.63 (3.08-4.23)	3.31 (2.59-4.16)	3.81 (3.03-4.79)	2.99 (2.33-3.75)	3.45 (2.76-4.30)
Morocco	3.96 (3.34-4.66)	4.31 (3.67-5.06)	4.17 (3.28-5.21)	4.53 (3.55-5.78)	3.77 (2.97-4.65)	4.11 (3.24-5.12)
Mozambique	2.13 (1.79-2.51)	2.24 (1.86-2.65)	2.24 (1.75-2.84)	2.36 (1.85-2.98)	2.04 (1.60-2.57)	2.13 (1.67-2.75)
Myanmar	4.56 (3.81-5.37)	4.49 (3.75-5.29)	4.77 (3.68-5.99)	4.71 (3.63-5.96)	4.36 (3.43-5.56)	4.27 (3.36-5.36)
Namibia	2.59 (2.20-3.05)	2.64 (2.24-3.09)	2.72 (2.10-3.43)	2.78 (2.17-3.43)	2.47 (1.92-3.12)	2.51 (2.00-3.15)
Nepal	3.87 (3.27-4.57)	3.89 (3.30-4.59)	4.06 (3.22-5.09)	4.07 (3.23-5.20)	3.69 (2.89-4.63)	3.73 (2.89-4.61)
Netherlands	3.44 (3.25-3.65)	3.32 (3.10-3.56)	3.72 (3.44-4.02)	3.50 (3.17-3.84)	3.17 (2.93-3.46)	3.15 (2.87-3.45)
New Zealand	3.27 (3.15-3.41)	3.47 (3.33-3.63)	3.44 (3.25-3.64)	3.65 (3.43-3.89)	3.12 (2.94-3.30)	3.31 (3.11-3.51)
Nicaragua	3.15 (2.65-3.78)	3.22 (2.72-3.83)	3.30 (2.56-4.22)	3.37 (2.57-4.26)	3.00 (2.33-3.83)	3.09 (2.41-3.88)
Niger	3.11 (2.60-3.66)	2.92 (2.48-3.44)	3.24 (2.54-4.04)	3.05 (2.37-3.82)	2.98 (2.32-3.74)	2.79 (2.17-3.47)
Nigeria	2.81 (2.50-3.17)	2.82 (2.51-3.17)	2.94 (2.51-3.45)	2.96 (2.52-3.48)	2.69 (2.29-3.18)	2.69 (2.30-3.17)
Norway	3.67 (3.10-4.36)	3.80 (3.24-4.49)	3.96 (3.10-4.96)	4.01 (3.15-5.06)	3.38 (2.63-4.18)	3.58 (2.77-4.51)
Oman	3.37 (2.81-4.01)	3.78 (3.17-4.46)	3.50 (2.70-4.38)	3.93 (3.08-4.93)	3.18 (2.50-4.00)	3.56 (2.82-4.46)
Pakistan	4.03 (3.42-4.73)	3.91 (3.32-4.66)	4.20 (3.31-5.24)	4.05 (3.18-5.14)	3.83 (3.01-4.75)	3.75 (2.97-4.77)
Palestinian Territory, Occupied	3.31 (2.77-3.93)	3.86 (3.24-4.57)	3.47 (2.72-4.48)	4.04 (3.16-5.13)	3.15 (2.45-3.96)	3.69 (2.87-4.65)
Panama	3.35 (2.84-4.00)	3.39 (2.89-3.98)	3.52 (2.82-4.42)	3.54 (2.79-4.55)	3.18 (2.51-3.99)	3.25 (2.54-4.03)
Papua New Guinea	2.45 (2.04-2.91)	2.45 (2.07-2.86)	2.57 (2.01-3.27)	2.58 (2.01-3.22)	2.32 (1.79-2.93)	2.33 (1.83-2.91)
Paraguay	4.01 (3.38-4.76)	4.31 (3.66-5.09)	4.23 (3.32-5.41)	4.52 (3.55-5.69)	3.80 (3.00-4.72)	4.10 (3.21-5.17)
Peru	3.05 (2.57-3.62)	3.07 (2.58-3.60)	3.20 (2.49-4.08)	3.22 (2.53-4.03)	2.91 (2.23-3.70)	2.91 (2.31-3.69)
Philippines	4.22 (3.55-4.99)	4.29 (3.65-5.10)	4.39 (3.44-5.50)	4.49 (3.50-5.68)	4.05 (3.19-5.09)	4.10 (3.20-5.29)
Poland	3.82 (3.57-4.07)	3.84 (3.61-4.06)	4.02 (3.67-4.40)	4.03 (3.68-4.38)	3.63 (3.29-3.98)	3.66 (3.37-4.00)
Portugal	3.88 (3.64-4.13)	4.24 (3.98-4.51)	4.20 (3.83-4.60)	4.46 (4.07-4.89)	3.58 (3.26-3.93)	4.03 (3.68-4.41)
Qatar	3.53 (2.87-4.28)	4.21 (3.34-5.17)	3.61 (2.78-4.55)	4.29 (3.25-5.44)	3.30 (2.59-4.27)	3.90 (2.98-5.04)
Romania	3.77 (3.21-4.43)	4.12 (3.46-4.83)	3.97 (3.11-4.99)	4.32 (3.42-5.43)	3.58 (2.85-4.41)	3.92 (3.08-4.93)

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Russian Federation	3.72 (3.53-3.93)	4.17 (3.95-4.40)	3.91 (3.64-4.24)	4.38 (4.07-4.72)	3.56 (3.29-3.84)	3.99 (3.69-4.29)
Rwanda	1.52 (1.23-1.88)	1.60 (1.31-1.95)	1.59 (1.18-2.11)	1.67 (1.25-2.14)	1.45 (1.07-1.91)	1.53 (1.12-2.03)
Saint Lucia	2.84 (2.54-3.15)	2.93 (2.58-3.30)	2.98 (2.56-3.43)	3.08 (2.60-3.60)	2.72 (2.32-3.16)	2.80 (2.34-3.31)
Saint Vincent and the Grenadines	2.70 (2.29-3.18)	2.82 (2.39-3.32)	2.83 (2.26-3.50)	2.94 (2.30-3.69)	2.58 (2.03-3.24)	2.70 (2.09-3.46)
Samoa	2.15 (1.97-2.36)	2.07 (1.82-2.34)	2.25 (1.99-2.56)	2.16 (1.82-2.57)	2.05 (1.80-2.31)	1.97 (1.66-2.32)
Sao Tome and Principe	2.37 (1.98-2.84)	2.36 (1.97-2.77)	2.48 (1.93-3.19)	2.47 (1.93-3.14)	2.26 (1.74-2.93)	2.25 (1.77-2.87)
Saudi Arabia	2.98 (2.47-3.54)	3.20 (2.63-3.78)	3.08 (2.41-3.92)	3.33 (2.54-4.15)	2.82 (2.17-3.65)	3.03 (2.36-3.90)
Senegal	2.98 (2.49-3.52)	3.15 (2.67-3.71)	3.11 (2.41-3.91)	3.32 (2.55-4.17)	2.85 (2.23-3.59)	2.99 (2.34-3.77)
Serbia	3.21 (2.69-3.79)	3.67 (3.05-4.39)	3.37 (2.67-4.18)	3.87 (2.94-4.95)	3.05 (2.35-3.88)	3.48 (2.68-4.40)
Seychelles	4.36 (3.63-5.20)	4.34 (3.62-5.12)	4.59 (3.54-5.84)	4.57 (3.55-5.74)	4.14 (3.18-5.21)	4.12 (3.21-5.17)
Sierra Leone	2.52 (2.10-2.99)	2.51 (2.11-2.94)	2.64 (2.09-3.34)	2.63 (2.05-3.25)	2.40 (1.88-3.03)	2.39 (1.89-2.96)
Singapore	5.03 (4.28-5.90)	5.14 (4.36-6.02)	5.25 (4.13-6.49)	5.37 (4.22-6.79)	4.81 (3.70-6.07)	4.92 (3.89-6.18)
Slovakia	3.64 (3.07-4.29)	4.23 (3.55-5.00)	3.82 (3.01-4.78)	4.46 (3.51-5.58)	3.48 (2.73-4.36)	4.02 (3.13-4.97)
Slovenia	3.87 (3.52-4.23)	4.23 (3.83-4.67)	4.07 (3.56-4.61)	4.43 (3.86-5.07)	3.68 (3.21-4.22)	4.02 (3.50-4.61)
Solomon Islands	2.26 (1.91-2.65)	2.33 (1.96-2.76)	2.37 (1.85-2.98)	2.44 (1.93-3.11)	2.14 (1.66-2.68)	2.22 (1.74-2.77)
Somalia	2.04 (1.71-2.42)	2.07 (1.77-2.43)	2.14 (1.67-2.69)	2.17 (1.74-2.71)	1.95 (1.53-2.45)	1.97 (1.53-2.51)
South Africa	2.41 (2.28-2.55)	2.48 (2.34-2.62)	2.53 (2.33-2.74)	2.61 (2.41-2.82)	2.30 (2.12-2.50)	2.37 (2.17-2.56)
Spain	3.72 (3.49-3.99)	4.02 (3.77-4.27)	4.01 (3.66-4.41)	4.24 (3.89-4.61)	3.44 (3.15-3.75)	3.81 (3.50-4.15)
Sri Lanka	3.92 (3.33-4.60)	3.87 (3.27-4.54)	4.10 (3.23-5.10)	4.07 (3.16-5.11)	3.75 (2.97-4.66)	3.69 (2.87-4.67)
Sudan	2.31 (1.96-2.71)	2.37 (2.01-2.79)	2.43 (1.92-3.02)	2.49 (1.93-3.17)	2.21 (1.74-2.79)	2.26 (1.77-2.82)
Suriname	2.66 (2.25-3.12)	2.89 (2.43-3.42)	2.79 (2.19-3.48)	3.03 (2.35-3.85)	2.53 (1.99-3.15)	2.76 (2.16-3.51)
Swaziland	2.63 (2.20-3.09)	2.53 (2.16-3.02)	2.77 (2.16-3.48)	2.67 (2.11-3.40)	2.52 (1.99-3.17)	2.42 (1.90-2.99)
Sweden	3.50 (3.32-3.70)	3.65 (3.46-3.85)	3.77 (3.50-4.05)	3.84 (3.56-4.15)	3.23 (3.01-3.47)	3.46 (3.22-3.71)
Switzerland	3.64 (3.41-3.89)	3.61 (3.40-3.85)	3.93 (3.60-4.29)	3.80 (3.48-4.13)	3.36 (3.08-3.67)	3.42 (3.13-3.74)
Syrian Arab Republic	3.80 (3.22-4.46)	4.18 (3.53-4.92)	3.97 (3.13-4.98)	4.37 (3.43-5.49)	3.64 (2.86-4.53)	3.99 (3.10-4.98)
Taiwan, Province of China	3.40 (3.12-3.69)	3.92 (3.66-4.17)	3.55 (3.14-3.99)	4.10 (3.72-4.48)	3.23 (2.85-3.61)	3.74 (3.40-4.11)
Tajikistan	5.03 (4.23-5.97)	5.40 (4.64-6.27)	5.29 (4.12-6.55)	5.70 (4.47-7.26)	4.79 (3.76-5.97)	5.13 (4.01-6.36)
Tanzania, United Republic of	2.81 (2.53-3.14)	2.75 (2.45-3.08)	2.94 (2.52-3.43)	2.88 (2.46-3.42)	2.69 (2.28-3.16)	2.62 (2.20-3.08)
Thailand	5.23 (4.82-5.66)	5.31 (4.88-5.75)	5.49 (4.94-6.15)	5.58 (4.97-6.18)	4.99 (4.46-5.58)	5.06 (4.54-5.65)
Timor-Leste	4.59 (3.83-5.38)	4.47 (3.71-5.32)	4.80 (3.78-5.98)	4.69 (3.61-5.91)	4.38 (3.45-5.56)	4.25 (3.39-5.37)
Togo	2.81 (2.40-3.33)	2.78 (2.36-3.34)	2.96 (2.29-3.82)	2.94 (2.30-3.77)	2.67 (2.12-3.35)	2.64 (2.09-3.29)
Tonga	2.61 (2.17-3.10)	2.73 (2.28-3.18)	2.72 (2.10-3.47)	2.88 (2.21-3.61)	2.50 (1.94-3.18)	2.58 (2.00-3.32)
Trinidad and Tobago	2.75 (2.51-3.01)	2.93 (2.63-3.23)	2.90 (2.55-3.28)	3.07 (2.64-3.56)	2.62 (2.30-2.95)	2.80 (2.43-3.19)
Tunisia	4.12 (3.51-4.91)	4.43 (3.72-5.23)	4.31 (3.37-5.44)	4.63 (3.61-5.83)	3.93 (3.09-4.91)	4.24 (3.32-5.34)
Turkey	3.76 (3.50-4.06)	4.10 (3.80-4.43)	3.94 (3.51-4.39)	4.30 (3.85-4.78)	3.59 (3.22-3.97)	3.91 (3.50-4.37)
Turkmenistan	5.10 (4.35-6.06)	5.43 (4.64-6.35)	5.35 (4.27-6.69)	5.69 (4.48-7.14)	4.87 (3.92-6.12)	5.20 (4.12-6.38)

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Uganda	1.95 (1.58-2.37)	2.11 (1.75-2.52)	2.05 (1.55-2.68)	2.21 (1.72-2.82)	1.86 (1.39-2.43)	2.00 (1.54-2.54)
Ukraine	3.85 (3.25-4.53)	4.19 (3.56-4.93)	4.05 (3.18-5.00)	4.41 (3.45-5.46)	3.68 (2.88-4.69)	4.01 (3.13-5.05)
United Arab Emirates	3.40 (2.73-4.16)	3.67 (2.97-4.47)	3.50 (2.64-4.48)	3.76 (2.92-4.78)	3.16 (2.38-4.12)	3.43 (2.65-4.39)
United Kingdom	3.48 (3.32-3.64)	3.61 (3.45-3.78)	3.75 (3.53-4.02)	3.80 (3.57-4.05)	3.21 (3.02-3.42)	3.42 (3.22-3.63)
United States	3.44 (3.35-3.53)	3.60 (3.50-3.70)	3.62 (3.48-3.77)	3.78 (3.63-3.93)	3.26 (3.14-3.40)	3.43 (3.29-3.56)
Uruguay	2.77 (2.34-3.27)	2.73 (2.32-3.18)	2.90 (2.24-3.65)	2.87 (2.27-3.58)	2.65 (2.09-3.35)	2.60 (2.05-3.28)
Uzbekistan	5.34 (4.50-6.25)	5.63 (4.83-6.53)	5.62 (4.47-6.93)	5.91 (4.67-7.41)	5.08 (4.04-6.39)	5.36 (4.28-6.66)
Vanuatu	2.17 (1.83-2.56)	2.24 (1.90-2.65)	2.26 (1.75-2.88)	2.33 (1.80-2.95)	2.07 (1.63-2.61)	2.14 (1.64-2.70)
Venezuela, Bolivarian Republic of	3.37 (2.84-3.92)	3.55 (3.01-4.18)	3.52 (2.81-4.39)	3.72 (2.92-4.66)	3.22 (2.52-3.98)	3.39 (2.65-4.21)
Viet Nam	4.48 (3.82-5.27)	4.59 (3.81-5.46)	4.67 (3.70-5.88)	4.83 (3.69-6.16)	4.31 (3.35-5.39)	4.37 (3.43-5.47)
Yemen	3.27 (2.76-3.86)	3.37 (2.82-4.05)	3.43 (2.65-4.38)	3.55 (2.74-4.53)	3.13 (2.46-3.94)	3.21 (2.48-4.13)
Zambia	2.27 (1.91-2.69)	2.27 (1.91-2.70)	2.39 (1.84-3.03)	2.38 (1.91-3.00)	2.15 (1.67-2.70)	2.17 (1.70-2.71)
Zimbabwe	3.06 (2.82-3.29)	3.10 (2.81-3.39)	3.21 (2.85-3.59)	3.25 (2.83-3.66)	2.92 (2.59-3.23)	2.95 (2.58-3.39)

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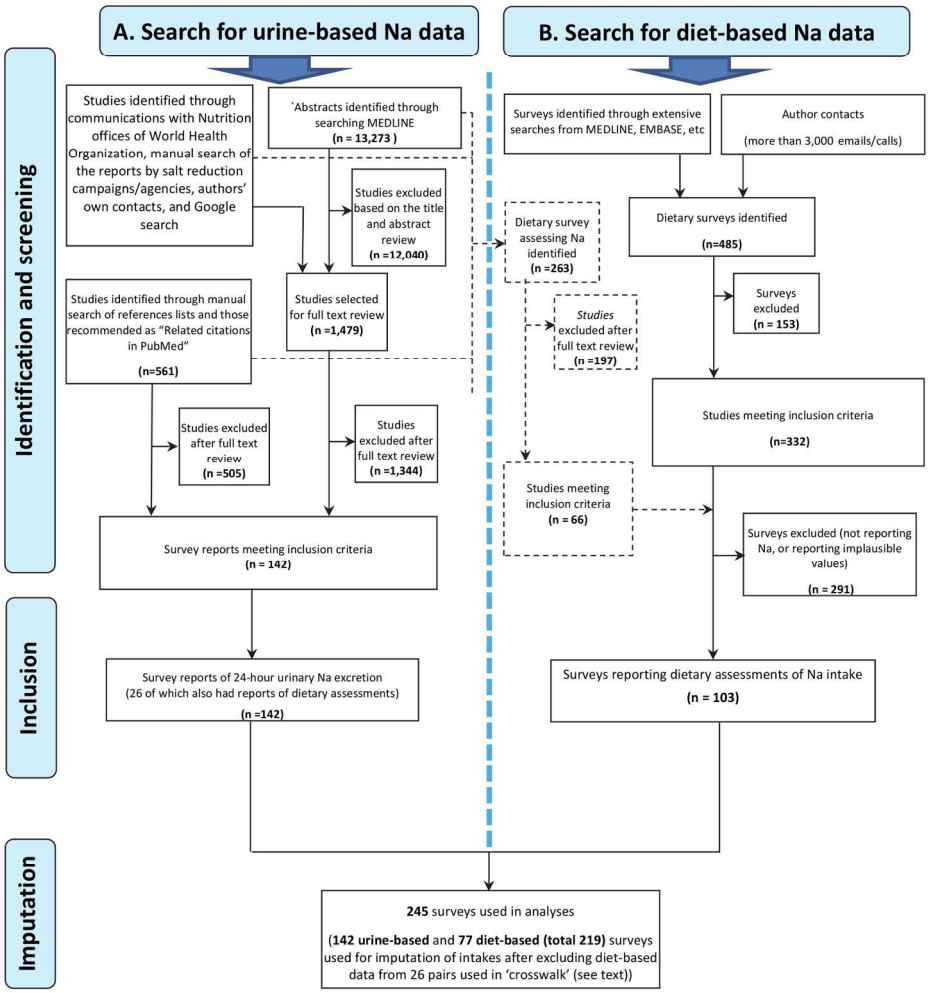

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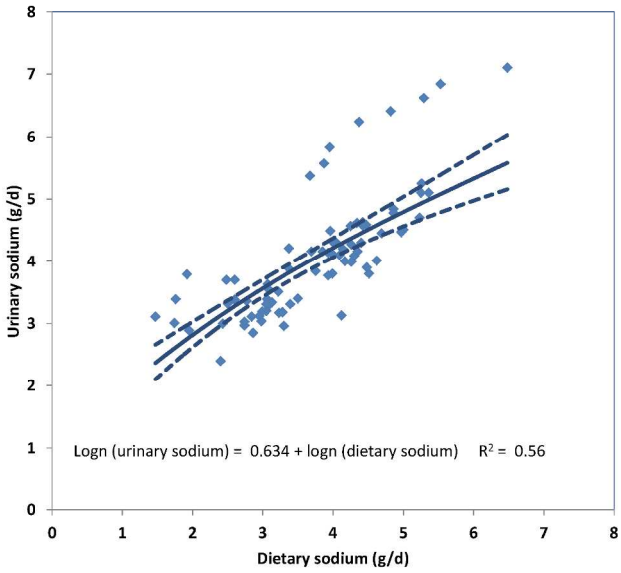

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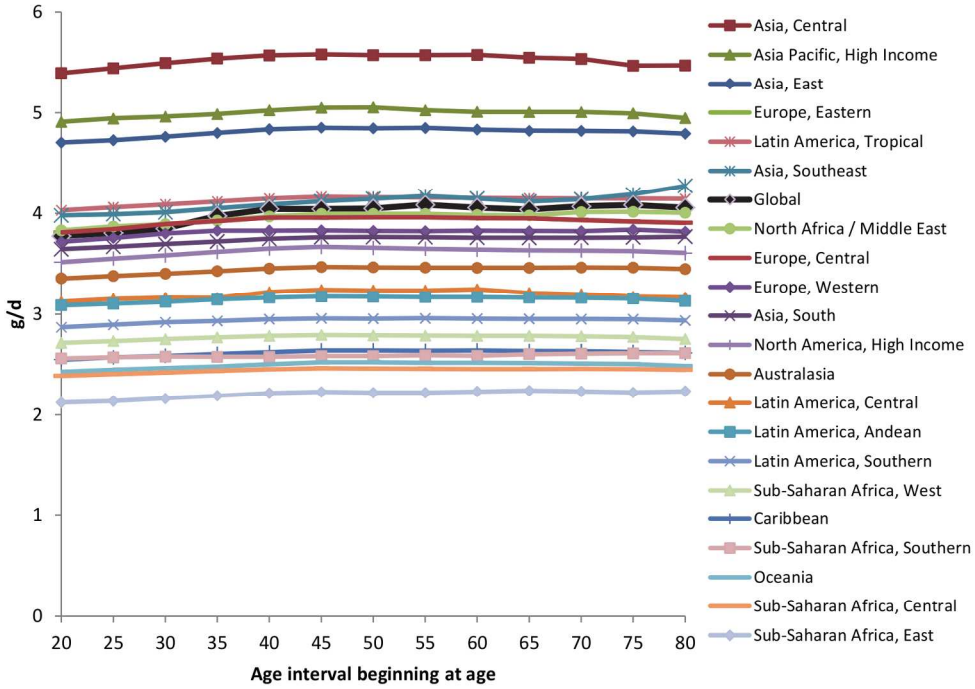

168x121mm (300 x 300 DPI)

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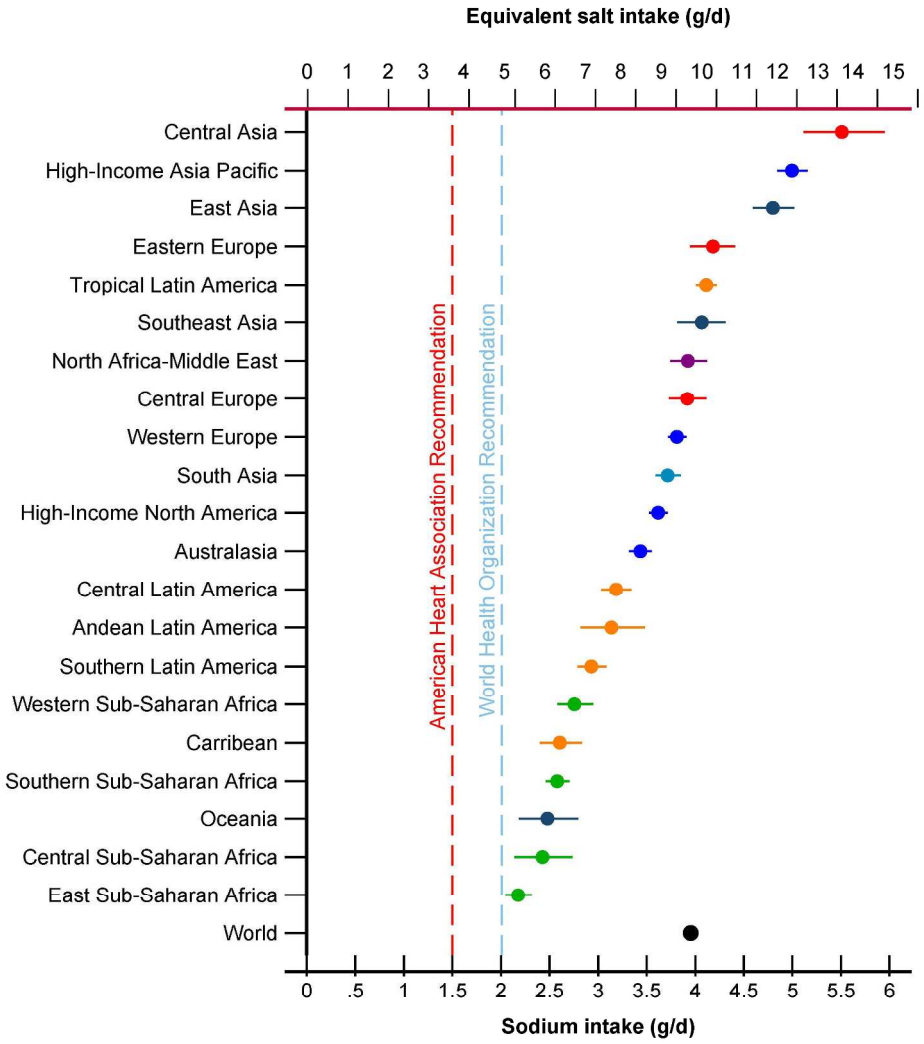

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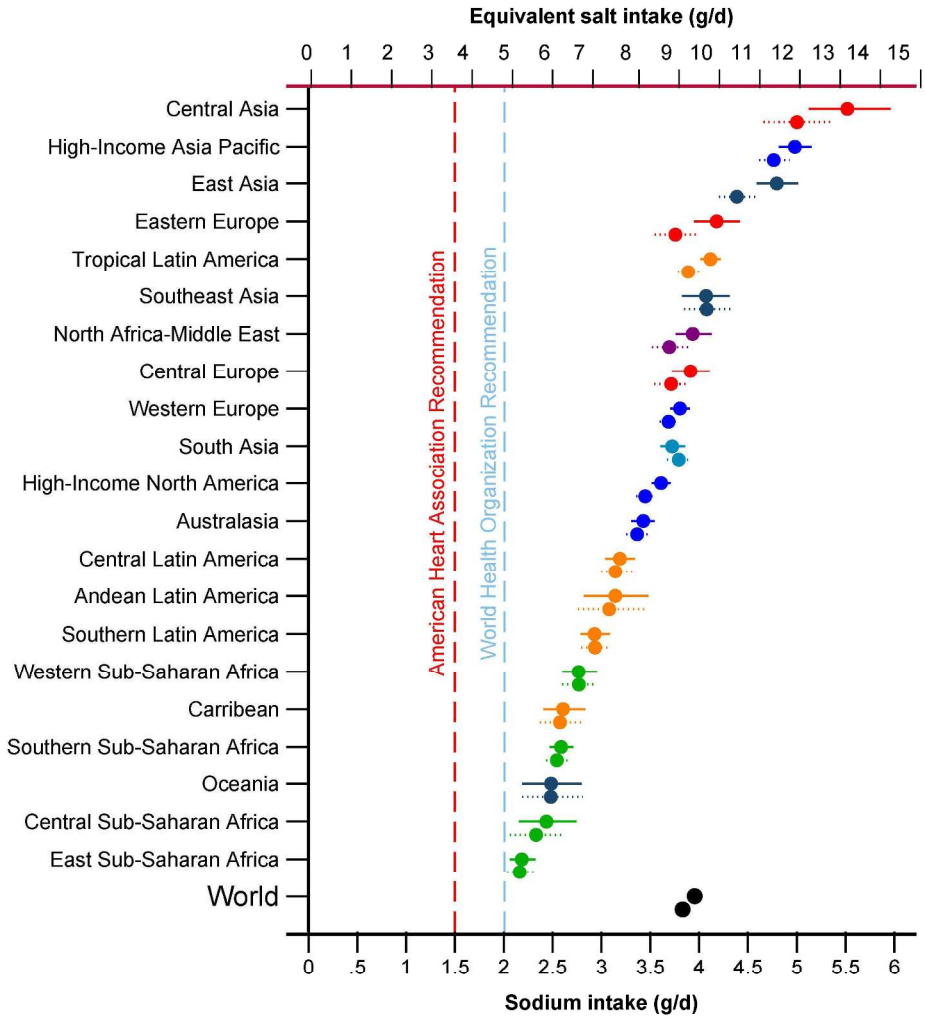

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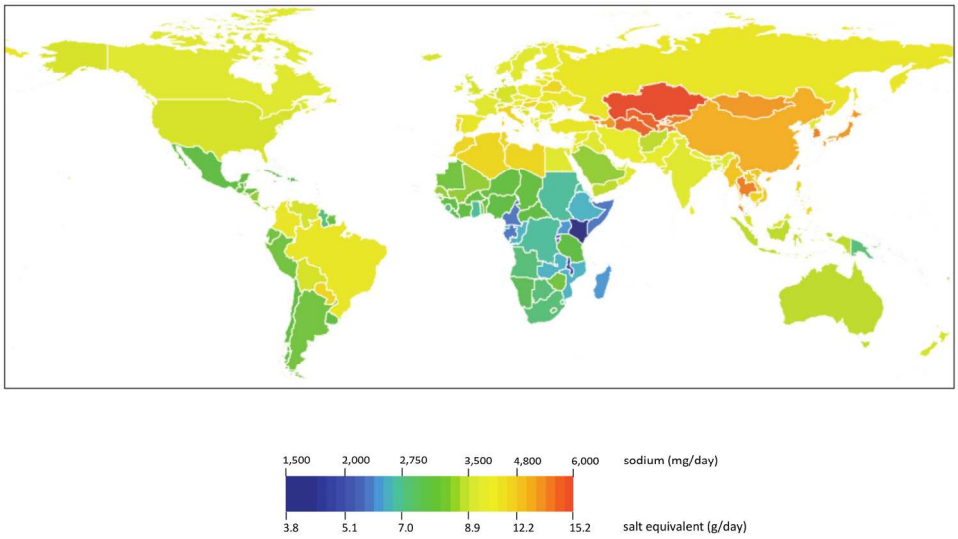

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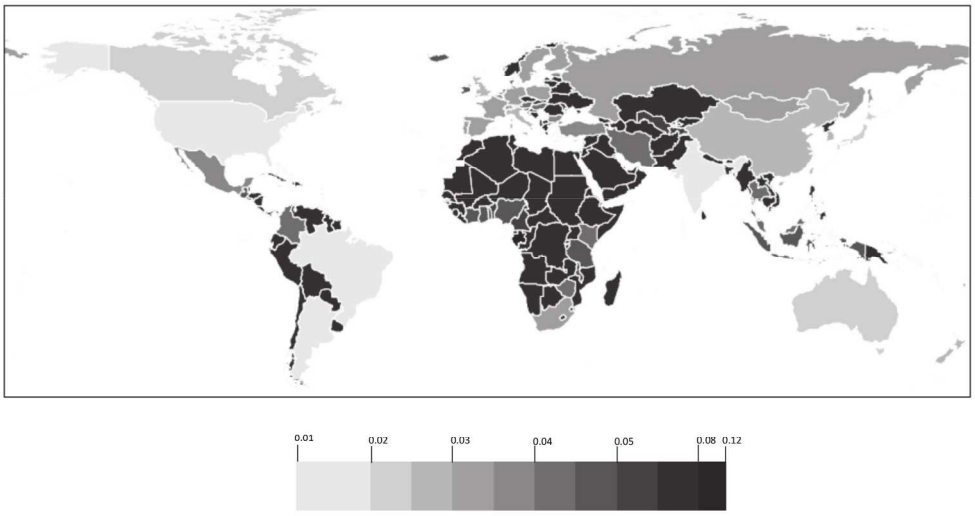

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METHODOLOGY SUPPLEMENT. THE IMPUTATION MODEL, DISMOD III

Modeling Strategy[i]

As sodium exposure data are available for only selected country-time periods, we estimated levels of sodium excretion for all country-time periods using an age-integrating Bayesian hierarchical model (DisMod III). The model includes fixed effects for study-specific and national-level covariates, and random effects by GBD super region, region, and country. Estimates for males and females in single year age groups, for 1990, 2005, and 2010 are produced.

We used both study-specific and national-level covariates in the model. We included one study-specific dummy variable to indicate whether the data are from non-nationally-representative studies/surveys. In addition, we allowed the variance of sub-national-level data to be different from nationally-representative data.

Time-varying country-level covariates were used in the model to inform the global and country-level trends and are not study-specific. We used data from the Food Balance Sheets of the Food and Agriculture Organization of the United Nations (FAO)[1] which captures a country's annual food availability for human consumption based on reported local production, imports and exports adjusted for other uses (livestock, seed). Taking into account that many of the food covariates are very collinear (for example, red meat, pig meat, and animal fats), and that consuming more of one food necessitates consuming less of other types, we used principal component analysis to generate four factor variables from the FAO data, based on the criteria that each factor must have an eigenvalue greater than one. Table S1 below shows the factor loadings on each of the 14 FAO variables, for the four factors (components). Although interpretation of these factor variables is not clear cut, red meats, animal fats, and pig meats have the highest loading in factor 1. Thus, factor 1 can be thought of as representing unhealthy meats. Seafood omega 3s, plant omega 6, whole grains, nuts, and vegetables have the highest loading in factor 2; fruits, legumes and nuts

[i] Text from the following source is used here with permission: Andrews K, Carnahan E, Ezzati M, Lim S, Murray C, and Sanman E. GBD 2010 Estimation Strategy Report for Attributable Burden to High Dietary Sodium Consumption, Unpublished report, Institute for Health Metrics and Evaluation, University of Washington, 2012.

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have the highest loading in factor 3. Factor 4 has the highest loading in sugars, stimulants, and saturated fats.

Lagged- distributed income (LDI) was also included as a country-level covariate. LDI per capita is GDP per capita smoothed with a 10-year weighted moving average.[2] We use LDI instead of straight GDP because it is more predictive of changes in health. Although GDP can experience drastic changes from year to year, changes in health and related outcomes are slower to change, meaning that the smoother measure of LDI more accurately predicts changes in health. The sources of GDP used are the Penn World Tables, The Maddison Project, the UN Statistics Agency, the World Bank, and the IMF (see[2] for detailed source information). The equation used to generate LDI:

LDI_y = (GDP per capita$_y$ + 0.9(GDP per capita$_{y-1}$) + 0.8(GDP per capita$_{y-2}$) + 0.7(GDP per capita$_{y-3}$) + 0.6(GDP per capita$_{y-4}$) + 0.5(GDP per capita$_{y-5}$) + 0.4(GDP per capita$_{y-6}$) + 0.3(GDP per capita$_{y-7}$) + 0.2(GDP per capita$_{y-8}$) + 0.1(GDP per capita$_{y-9}$))/5.5 (5.5 = the sum of the weights).

Table S2 presents the effect size estimated for the study-level and national covariates from the DisMod III model.

Table S1. Factor loadings used to create 4 FAO factor variables

Variable	Component 1	Component 2	Component 3	Component 4
Red meats	0.3614	0.1615	-0.1718	-0.1419
Animal fats	0.3546	0.1596	-0.1604	-0.1271
Fruits	0.1012	0.0712	0.6665	-0.1791
Omega- 6	0.3229	-0.296	0.0186	0.0288
Omega-3	0.0741	0.427	0.2574	0.3815
Whole grains	0.237	-0.3968	-0.1517	0.3163
Nuts	0.221	-0.2804	0.4033	0.1464
Vegetables	0.2777	-0.3197	0.1922	0.2252
Pulses/legumes	-0.2044	-0.146	0.4078	-0.4013
Alcohol	0.2896	0.0907	0.0103	-0.4957
Pig meat	0.3654	0.194	-0.1009	-0.2432
Saturated fats	0.0318	0.5036	0.171	0.3399
Stimulants	0.3031	0.1163	0.0559	-0.0203
Sugars	0.2992	0.0277	0.0493	0.1765

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Table S2. Effect sizes and standard errors for both study-level and national covariates.

Covariate	Mean Effect Size	Effect Size SE
Study-level covariate: non-nationally-representative data	0.995	0.013
Study-level covariate: male	0.135	0.011
National covariate: log LDI per capita	-0.100	0.051
National covariate: FAO factor 1	0.271	0.043
National covariate: FAO factor 2	-0.100	0.023
National covariate: FAO factor 3	-0.152	0.030
National covariate: FAO factor 4	-0.007	0.029

Standard deviations were estimated using a regression model using mean exposure, age and sex as the predictors.

Model output

Figure S1 gives an annotated output from the Dismod model.

Figures S2 to S5 show the model outputs for the regions.

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Figure Legends

Figure S1. Guide to model outputs for regions

Figure S2. Model output for regions (1)

Figure S3. Model output for regions (2)

Figure S4. Model output for regions (3)

Figure S5. Model output for regions (4)

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1 FAO FAOSTAT: Food Balance Sheets. FAO. Available: http://faostat3.fao.org/home/index.html#DOWNLOAD, accessed April 1, 2012.

2 James SL, Gubbins P, Murray CJ, Gakidou E Developing a comprehensive time series of GDP per capita for 210 countries from 1950 to 2015. Popul Health Metr 2012;10:12.

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Supplementary Table. Surveys and survey pairs used in the assessment of sodium exposure with identification of sources for published reports and of corresponding members where data was provided on request. Survey pairs, indicated by B (for Both) under Metrics, include both urine-based and diet-based surveys for the same source population.

Country (with included surveys)	Survey name or report authors (CM, corresponding members – see main text)	Metrics (Urine, Diet, Both)	Mid-year of data collection	National, Subnational	Sample size			Age range	Urine method (where applic.)[1]	Diet method (where applic.)[2]
					M	F	T[3]			
Asia-Pacific, High Income										
Japan	INTERSALT, Osaka [1]	U	1986	S	100	97		20-59	2	
Japan	INTERSALT, Tochigi [1]	U	1986	S	95	98		20-59	2	
Japan	INTERSALT, Toyama [1]	U	1986	S	100	100		20-59	2	
Japan	Liu et al. [2]	U	1991	N	484	542		48-56	2	
Japan	Kawamura et al. [3]	U	1993	S	90	50		30-65	2	
Japan	National Nutrition Survey (in Japan) [4]	D	1995	N	4,976	5,790		20-100		3
Japan	Sasaki et al. [5]	B	1996	S	308	138		20-25	4	3
Japan	The Japan Public Health Center-based Prospective Study (JPHC Study) [6]	D	1996	S	45,593	52,175		45-74		2
Japan	INTERMAP, Aito Town [7]	B	1997	S	260	258		40-59	2	3
Japan	INTERMAP, Sapporo [7]	B	1997	S	298	296		40-59	2	3
Japan	INTERMAP, Toyama [7]	B	1997	S	298	300		40-59	2	3
Japan	INTERMAP, Wakayama [7]	B	1997	S	292	288		40-59	2	3
Japan	National Nutrition Survey (in Japan) [8]	D	1998	N	5,067	5,850		20-100		3
Japan	Kimira et al. [9]	B	1999	S			438	27-84	4	3
Japan	The Japan Public Health Center-based Prospective Study (JPHC Study) [10]	D	2001	S	43,073	49,229		50-79		2
Republic of Korea	Korea National Health and Nutrition Examination	D	2005	N	2,877	3,563		20-100		3

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Country (with included surveys)	Survey name or report authors (CM, corresponding members – see main text)	Metrics (Urine, Diet, Both)	Mid-year of data collect-ion	Nation-al, Subnat-ional	Sample size			Age range	Urine method (where applic.)[1]	Diet method (where applic.)[2]
					M	F	T[3]			
	Survey (KNHANES) III [11]									
Republic of Korea	INTERSALT, Pusan [1]	U	1986	S	100	98		20-59	2	
Asia, Central										
Mongolia	Yamada et al. [12]	U	1998	N	571	598		20-44	4	
Asia, East										
China	Zhao GS et al. (1 of 3) [13]	U	1983	S	92			40-59	4	
China	Zhao GS et al. (2 of 3) [13]	U	1983	S	82			40-59	4	
China	Zhao GS et al. (3 of 3) [13]	U	1983	S	83			40-59	4	
China	Zhou BF et al. (1 of 9) [14]	D	1983	S	342			35-59		1
China	Zhou BF et al. (2 of 9) [14]	D	1983	S	124			35-59		1
China	Zhou BF et al. (3 of 9) [14]	D	1983	S	51			35-59		1
China	Zhou BF et al. (4 of 9) [14]	D	1983	S	119			35-59		1
China	Zhou BF et al. (5 of 9) [14]	D	1983	S	181			35-59		1
China	Zhou BF et al. (6 of 9) [14]	D	1983	S	215			35-59		1
China	Zhou BF et al. (7 of 9) [14]	D	1983	S	85			35-59		1
China	Zhou BF et al. (8 of 9) [14]	D	1983	S	212			35-59		1
China	Zhou BF et al. (9 of 9) [14]	D	1983	S	195			35-59		1
China	INTERSALT, Beijing [1]	U	1986	S	100	100		20-59	2	
China	INTERSALT, Nanning [1]	U	1986	S	100	100		20-59	2	
China	INTERSALT, Tianjin [1]	U	1986	S	100	100		20-59	2	
China	Liu et al. [2]	U	1992	N	403	408		48-56	2	
China	Nan et al. [15]	D	1992	N	1133	1184		20-64		1
China	INTERMAP, Beijing [7]	B	1997	S	266	278		40-59	2	3
China	INTERMAP, Guangxi [7]	B	1997	S	280	276		40-59	2	3

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					M	F	T[3]			
China	INTERMAP, Shanxi [7]	B	1997	S	286	292		40-59	2	3
China	2002 China National Nutrition and Health Survey [16]	D	2002	N	24,020	27,109		20-101		1
Taiwan	INTERSALT, San Chilo Village [1]	U	1986	S	89	92		20-59	2	
Taiwan	2005-2008 Nutrition and Health Survey in Taiwan [17]	D	2006	N	1,446	1,462		20-100		3
Asia, South										
India	INTERSALT, New Delhi [1]	U	1986	S	100	99		20-59	2	
India	INTERSALT, Stok, Ladakh [1]	U	1986	S	100	100		20-59	2	
India	National Nutrition Monitoring Bureau (NNMB) Rural Surveys [18]	D	1996	S	3,863	4,160		20-100		3
India	National Nutrition Monitoring Bureau (NNMB) Rural Surveys [19]	D	2000	S	8,314	8,888		20-100		3
India	Radhika et al. [20]	D	2003	S			1902	20-79		2
India	National Nutrition Monitoring Bureau (NNMB) Rural Surveys [21]	D	2005	S	8,824	9,468		20-100		3
Asia, South-East										
Indonesia	Mustafa et al. [22]	U	2003	S		15		25-55	4	
Malaysia	Malaysian Adult Nutrition Survey 2002 [23]	D	2002	N	3,117	3,340		20-59		3
Malaysia	Malaysian Adults Nutrition Survey 2003 [23]	D	2003	N	3,464	3,464		20-59		3
Thailand	Calcium Status, Factors Affecting Calcium and Bone Status in Healthy Thais Living in Bangkok [24]	D	1993	S	153	243		20-80		3
Thailand	Kwanmaung et al. (1 of 2) [25]	U	1998	S			18	20-79	4	
Australasia										
Australia	Beard et al. [26]	U	1989	S	22	32		24-69	4	
Australia	Notowidjojo et al. [27]	U	1992	S	64	64		20-64	4	
Australia	Beard et al. [28]	U	1995	S	87	107		20-70	2	
Australia	Margerison [29] (and CM)	U	2003	S	79	65		30-74	4	

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					M	F	T[3]			
Australia	Charlton et al. [30]	U	2007	S		78		20-56	4	
Australia	Land et al. [31] (and CM)	U	2011	S	144	162		20-88	4	
New Zealand	Simpson et al. [32]	U	1981	S	473	502		20-93	4	
New Zealand	Thomson and Colls [33]	U	1995	S	313	319		20-69	4	
New Zealand	NZ National Nutrition Survey 1997 [34]	D	1997	N	1,678	2,884		20-84		1
Caribbean										
Barbados	Cooper et al. [35]	U	1992	S			813	25-74	4	
Barbados	Identifying new genetic and obesity-related factors contributing to prostate and breast cancer risk in persons of African descent [36]	D	2005	N	152	128		31-88		2
Belize	Simmons et al. [37]	U	1980	S	392			20-94	4	
Jamaica	Cooper et al. [35]	U	1994	S			1.357	25-74	4	
Jamaica	Social and dietary determinants of body max index of adult Jamaicans [38]	D	1994	N	363	560		25-74		2
St. Lucia	Cooper et al. [35]	U	1992	S			1.089	25-74	4	
Trinidad and Tobago	INTERSALT, Plymoth-Bethesda [1]	U	1986	S	84	92		20-59	2	
Europe, Central										
Bulgaria	Powles et al. [39] (and CM)	U	1999	S	74	84		45-74	1	
Bulgaria	National Nutrition Survey [40]	D	2004	N	410	443		20-100		3
Hungary	INTERSALT, Porcsalam village [1]	U	1986	S	100	100		20-59	2	
Poland	INTERSALT, Warsaw [1]	U	1986	S	100	100		20-59	2	
Poland	Household Food Consumption and Anthropometric Survey [41]	D	2000	N	1,247	1,574		20-100		3
Slovenia	Ribic et al. [42]	U	2007	N	61	82		25-65	2	
Europe, East										

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					M	F	T[3]			
Estonia	Estonian National Dietary Survey [43]	D	1997	N	878	1,098		20-65		3
Russian Federation	INTERSALT, Moscow [1]	U	1986	S	97	97		20-59	2	
Europe, West										
Austria	Austrian Study on Nutritional Status 2007 [44]	D	2007	N	925	1,547		20-100		3
Belgium	Staessen et al. [45]	U	1980	S	273	255		20-88	4	
Belgium	INTERSALT, Charleroi [1]	U	1986	S	82	75		20-59	2	
Belgium	INTERSALT, Ghent [1]	U	1986	S	100	100		20-59	2	
Belgium	Zhang et al. [46]	B	1997	N	4,248	3,996		25-74	2	3
Belgium	Vandevijvere et al. [47]	U	2007	S	60	54		25-65	4	
Belgium	Vandevijvere et al. [47]	U	2009	S	66	69		25-65	4	
Denmark	INTERSALT, Glostrup [1]	U	1986	S	99	100		20-59	2	
Denmark	Dietary Habits of Denmark [48]	D	2001	N	1,448	1,486		20-100		1
Denmark	Andersen et al. [49]	U	2006	S	37	50		20-55	1	
Finland	Laatikainen et al. (2 of 11) [50]	U	1982	S	247	237		25-64	3	
Finland	Laatikainen et al. (6 of 11) [50]	U	1982	S	213	215		25-64	3	
Finland	Laatikainen et al. (8 of 11) [50]	U	1982	S	232	238		25-64	3	
Finland	INTERSALT, Turku [1]	U	1986	S	100	100		20-59	2	
Finland	Laatikainen et al. (3 of 11) [50]	U	1987	S	199	210		25-64	3	
Finland	Laatikainen et al. (7 of 11) [50]	U	1987	S	180	220		25-64	3	
Finland	Laatikainen et al. (9 of 11) [50]	U	1987	S	150	192		25-64	3	
Finland	FINDIET 1992 [51]	D	1992	N	870	991		25-64		1
Finland	Laatikainen et al. (11 of 11) [50]	U	2002	S	127	156		25-64	2	
Finland	Laatikainen et al. (4 of 11) [50]	U	2002	S	168	174		25-64	2	
Finland	Reinivuo et al. [52]	D	2002	S	168	174		25-64		1

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					M	F	T [3]			
Finland	Reinivuo et al. [52]	D	2002	S	128	156		25-64		1
Finland	Reinivuo et al. [52]	D	2002	S	127	156		25-64		1
Finland	FINDIET 2007 [53]	D	2007	N	959	1,080		25-74		1
France	Meneton et al. (1 of 2) [54]	D	1999	N	672	802		20-92		1
France	du Cailar et al. [55]	U	2001	S			855	20-70	4	
France	Etude nationale nutrition santé (ENNS); National Nutrition and Health survey [56]	D	2006	N	975	1,701		20-74		1
Germany	INTERSALT, Bernried [1]	U	1986	S	99	98		20-59	2	
Germany	INTERSALT, Cottbus [1]	U	1986	S	99	99		20-59	2	
Germany	INTERSALT, Heidelberg [1]	U	1986	S	97	99		20-59	2	
Germany	German Nutrition Survey 1998 [57]	D	1998	N	1,691	2,170		20-79		2
Germany	Nationale Verzehrs Studie II, Ergebnisbericht, Teil 2 [58]	D	2006	N	6381	7578		20-80		1
Iceland	INTERSALT, Reykajavik and district [1]	U	1986	S	100	100		20-59	2	
Iceland	Dietary Survey of the Icelanders [59]	D	1990	N	531	564		20-80		3
Iceland	The Diet of Icelanders, Dietary Survey of The Icelandic Nutrition Council 2002 [60]	D	2002	N	517	601		20-80		3
Iceland	Olafsdottir et al. [61]	B	2003	S		120		25-55	1	3
Ireland	Flynn et al. [62]	U	1987	S	46	48		20-60	4	
Israel	Mabat First Israeli National Health and Nutrition Survey [63]	D	2000	N	1,540	1,700		25-64		3
Israel	Mabat National Health and Nutrition Survey of the Elderly (Zahav) [64]	D	2005	N	833	949		65-100		3
Italy	INTERSALT, Bassiano [1]	U	1986	S	99	100		20-59	2	
Italy	INTERSALT, Gubbio [1]	U	1986	S	99	100		20-59	2	
Italy	INTERSALT, Mirano [1]	U	1986	S	100	100		20-59	2	

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					M	F	T [3]			
Italy	INTERSALT, Naples [1]	U	1986	S	100	100		20-59	2	
Italy	Pavan et al. (1 of 4) [65]	D	1994	S			370	22-89		2
Italy	INN-CA 1994-96 [66]	D	1995	N	701	888		20-100		1
Italy	Venezia et al. [67]	U	2003	S	940			25-75	4	
Malta	INTERSALT, Dingli village [1]	U	1986	S	100	100		20-59	2	
Netherlands	INTERSALT, Zutphen [1]	U	1986	S	100	99		20-59	2	
Netherlands	Ocke et al. (CM)	U	2006	S	120	171		20-74	4	
Portugal	INTERSALT, Cartaxo Village [1]	U	1986	S	99	99		20-59	2	
Portugal	Polonia et al. [68]	U	2000	S			426	20-84	2	
Portugal	EPITeen Project [69]	D	2003	N	1,163	1,811		20-100		3
Spain	INTERSALT, Manresa [1]	U	1986	S	100	100		20-59	2	
Spain	INTERSALT, Torrejon [1]	U	1986	S	100	100		20-59	2	
Spain	Schroder et al. [70]	D	1995	S			1,567	25-54		1
Spain	The Catalan Nutrition Survey (ENCAT 2002-2003) and Serra Majem and Ribas, 2007 and Serra-Majem L et al., 2007 and Serra Majem et al., 2006 [71]	D	2003	N	869	1,054		20-100		1
Spain	Ortega et al. [72]	U	2009	N	196	222		20-60	4	
Sweden	Dietary habits and nutrient intake in Sweden 1989 [73]	D	1989	N	743	770		20-74		3
Sweden	Dietary habits and nutrient intake in Sweden 1997-98 [74]	D	1997	N	565	608		20-79		3
Switzerland	Chappuis et al. [75]	U	2010	N	663	687		20-79	2	
United Kingdom	Bingham et al. [76]	U	1985	S	71	50		25-44	1	
United Kingdom	Dietary and Nutritional Survey of British Adults 1986 [77]	B	1986	N	1,597	1,620		20-64	1	3
United Kingdom	INTERSALT, Belfast [1]	U	1986	S	99	100		20-59	2	
United Kingdom	INTERSALT, Birmingham [1]	U	1986	S	100	100		20-59	2	

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					M	F	T[3]			
United Kingdom	INTERSALT, Bridgend, South-Wales [1]	U	1986	S	100	99		20-59	3	
United Kingdom	Fogarty et al. [78] (and CM)	U	1991	S	836	845		20-74	4	
United Kingdom	National Diet and Nutrition Survey: people aged 65 years and over [79]	D	1994	N	632	643		65-100		3
United Kingdom	Khaw et al.(1 of 2) [80]	D	1995	S	3,583	4,013		45-79		1
United Kingdom	Khaw et al.(2 of 2) [80]	U	1995	S	160	180		45-79	1	
United Kingdom	INTERMAP, West Bromwich [7]	B	1997	S	282	276		40-59	2	3
United Kingdom	INTERMAP,Belfast [7]	B	1997	S	250	194		40-59	2	3
United Kingdom	National Diet and Nutrition Survey: adults aged 19-64 years 2000 [81]	B	2000	N	1,306	1,578		20-64	1	3
United Kingdom	Low Income Diet and Health Survey, 2003-2005 [82]	D	2004	N	1,021	1,910		20-100		1
United Kingdom	National Centre for Social Research [83]	U	2007	N	181	248		25-64	1	
United Kingdom	National Centre for Social Research [84]	U	2008	N	341	439		20-64	1	
United Kingdom	Scotish centre for Social Research [85]	U	2009	S	324	232		20-64	1	
Latin America, Central										
Colombia	INTERSALT, Tuquerres [1]	U	1986	S	96	95		20-59	2	
Guatemala	Melse-Boonstra et al. (4 of 4) [86]	U	1996	S		7		25-55	4	
Mexico	INTERSALT, Chihuahua [1]	U	1986	S	91	81		20-59	2	
Mexico	National Health and Nutrition Survey 2006 (Mexico) [87]	D	2005	N	5,898	9,848		20-59		2
Latin America, Southern										
Argentina	INTERSALT, Buenos Aires [1]	U	1986	S	100	100		20-59	2	
Argentina	Encuesta Nacional de Nutrición y Salud - National Nutrition and Health Survey (ENNyS) [88]	D	2004	N		4,429		20-49		3
Latin America,										

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					M	F	T[3]			
Tropical										
Brazil	Sarno et al. [89]	D	2002	N			48000	20-79		4
Brazil	Household Health Survey (ISA-SP) [90]	D	2003	S	724	806	1530	20-100		3
North Africa, Middle East										
Bahrain	National Nutrition Survey [91]	D	2000	N	1,120	1,181		20-70		3
Iran	Azizi et al. (1 of 2) [92]	D	1998	S			340	20-79		2
Iran	Azizi et al. (2 of 2) [92]	D	1998	S			343	20-79		2
Iran	Rahmani et al. [93]	D	2000	S			644	20-79		2
Iran	Rafiei et al. [94]	U	2001	S	304	608		20-60	4	
Kuwait	National Nutrition Survey for the State of Kuwait [95]	D	2008	N	403	517		20-100		3
Lebanon	National survey: Behavioral risk factor survey [96]	D	2008	N	1,207	1,385		20-100		2
Turkey	Dietary intake of adult population living in Ankara [97]	D	2005	S	348	1,136		20-84		3
Turkey	Erdem et al. [98]	U	2007	N	373	443		20-94	4	
North America, High Income										
Canada	INTERSALT, Labrador [1]	U	1986	S	78	83		20-59	2	
Canada	INTERSALT, St. Johns [1]	U	1986	S	100	100		20-59	2	
Canada	Canadian Community Health and Nutrition Survey [99]	D	2004	N	8,768	10,960		20-101		1
Canada	Garriguet [100]	D	2004	N	2,724	2,724		20-79		3
Canada	Shi et al. [101]	D	2004	N	3690	5177		30-79		3
USA	Holbrook et al. [102]	B	1981	S	24	32		20-53	4	1
USA	INTERSALT, Chicago [1]	U	1986	S	97	99		20-59	2	
USA	INTERSALT, Goodman, Blacks [1]	U	1986	S	93	93		20-59	2	

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					M	F	T[3]			
USA	INTERSALT, Goodman, Whites [1]	U	1986	S	99	99		20-59	2	
USA	INTERSALT, Jackson, Blacks [1]	U	1986	S	84	100		20-59	2	
USA	INTERSALT, Jackson, Whites [1]	U	1986	S	100	99		20-59	2	
USA	INTERSALT, Molokai, Hawaii [1]	U	1986	S	94	93		20-59	2	
USA	Cooper et al. [35]	U	1992	S			708	20-75	4	
USA	Espeland et al. [103]	B	1993	S			650	60-79	4	3
USA	Taylor et al. (1 of 2) [104]	U	1996	S		330		40-75	4	
USA	INTERMAP, Chicago [7]	B	1997	S	312	318		40-59	2	3
USA	INTERMAP, City of Woodlawn, Baltimore, Maryland [7]	B	1997	S	292	268		40-59	2	3
USA	INTERMAP, Corpus Christi, Hispanic [7]	B	1997	S	270	280		40-59	2	3
USA	INTERMAP, Corpus Christi, Non-Hispanic [7]	B	1997	S	272	272		40-59	2	3
USA	INTERMAP, Honolulu [7]	B	1997	S	272	262		40-59	2	3
USA	INTERMAP, Jackson [7]	B	1997	S	264	268		40-59	2	3
USA	INTERMAP, Minneapolis [7]	B	1997	S	260	260		40-59	2	3
USA	INTERMAP, Pittsburgh [7]	B	1997	S	264	256		40-59	2	3
USA	NHANES 2003-2006 [105]	D	2004	N	9,118	9,912		20-85		1
USA	Taylor et al. (2 of 2) [104]	U	2005	S		146		40-75	4	
Oceania										
American Samoa	American Samoa 1990 24 hr recall diet estimates [106]	D	1990	N	235	268		25-54		3
Niue	Taylor et al. [107]	U	1980	N	19	15		20-79	4	
Samoa	Western Samoa 1990 24 hr recall diet estimates [108]	D	1991	N	230	276		25-54		3
Sub-Saharan Africa, East										
Kenya	INTERSALT, Rambugu and Ndori villages [1]	U	1986	S	90	86		20-59	2	

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					M	F	T [3]			
Malawi	Simmons et al. (1 of 2) [109]	U	1983	S			78	20-79	4	
Malawi	Simmons et al. (2 of 2) [109]	U	1983	S			123	20-79	4	
Uganda	Pavan et al. (3 of 4) [65]	D	1994	S			138	22-89		2
United Republic of Tanzania	Pavan et al. (2 of 4) [65]	D	1994	S			232	22-85		
Sub-Saharan Africa, Southern										
South Africa	Barlow et al. (1 of 2) [110]	U	1982	S	150			30-50	4	
South Africa	Barlow et al. (2 of 2) [110]	U	1982	S	64			30-50	4	
South Africa	Food and nutrient availability in South African Households [111]	D	1995	N	416	502		20-99		2
South Africa	Charlton et al. (1 of 3) [112]	B	2002	S			220	20-65	4	3
South Africa	Charlton et al. (2 of 3) [112]	B	2002	S			224	20-65	4	3
South Africa	Charlton et al. (3 of 3) [112]	B	2002	S			206	20-65	4	3
South Africa	Maseko et al. [113]	U	2003	S			291	21-72	3	
Zimbabwe	INTERSALT, Harare [1]	U	1986	S	100	95		20-59	2	
Sub-Saharan Africa, Western										
Benin	Melse-Boonstra et al. (2 of 4) [86]	U	1996	S		13		22-55	4	
Cameroon	Cooper et al. [35]	U	1992	S			2828	25-74	4	
Cote d'Ivoire	Hess et al. (1 of 2) [114]	U	1997	S			52	20-79	3	
Cote d'Ivoire	Hess et al. (2 of 2) [114]	U	1997	S			51	20-79	3	
Ghana	Kerry et al. (1 of 2) [115]	U	2001	S			481	40-75	2	
Ghana	Kerry et al. (2 of 2) [115]	U	2001	S			532	40-75	2	
Nigeria	Cooper et al. [35]	U	1992	S			2509	45-94	3	

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[1] Quality control for urine collections:

1. PABA validation;
2. Exclusions based on observed/expected creatinine ratio or total urinary creatine (including Intersalt and InterMap);
3. Other strict urine collection protocols without use of PABA or creatinine;
4. Other collection protocol or not reported.

[2] Diet methods:

1. Multiple (≥2) short-term (up to 1 week) diet recalls/ records (with or without) correction for within-person variation;
2. Food frequency questionnaires;
3. Single short-term diet records/ recalls;
4. Household availability/ budget survey.

[3] For surveys where sex-specific data was not available.

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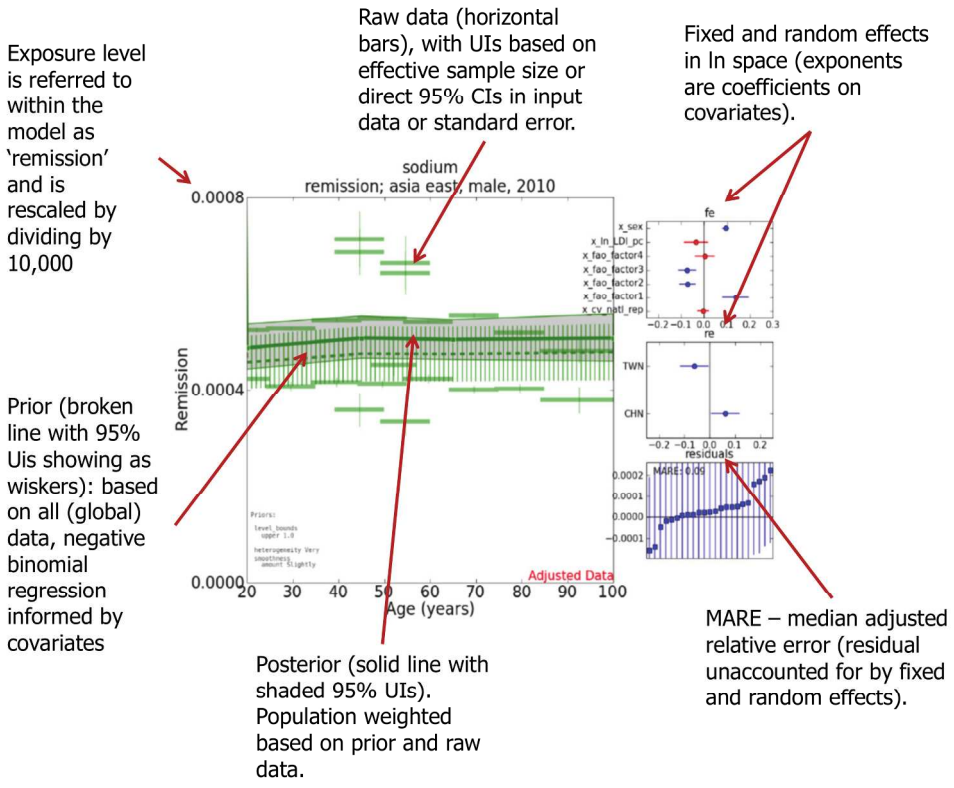

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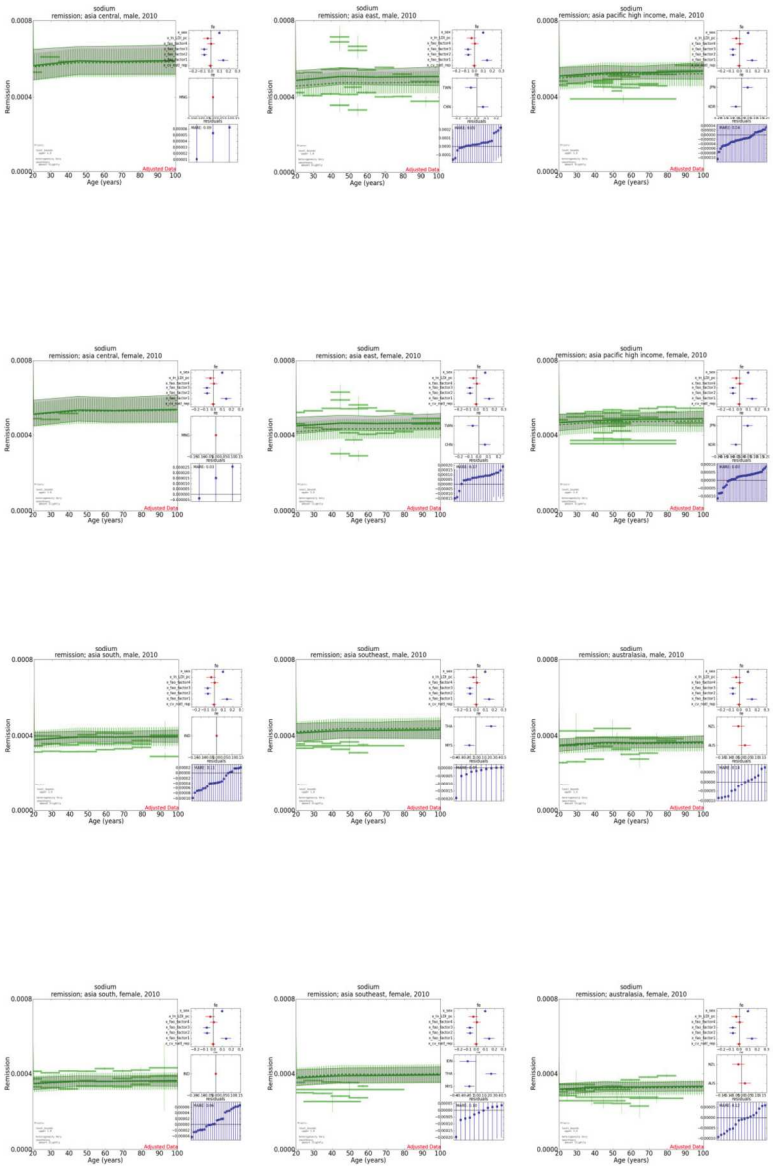

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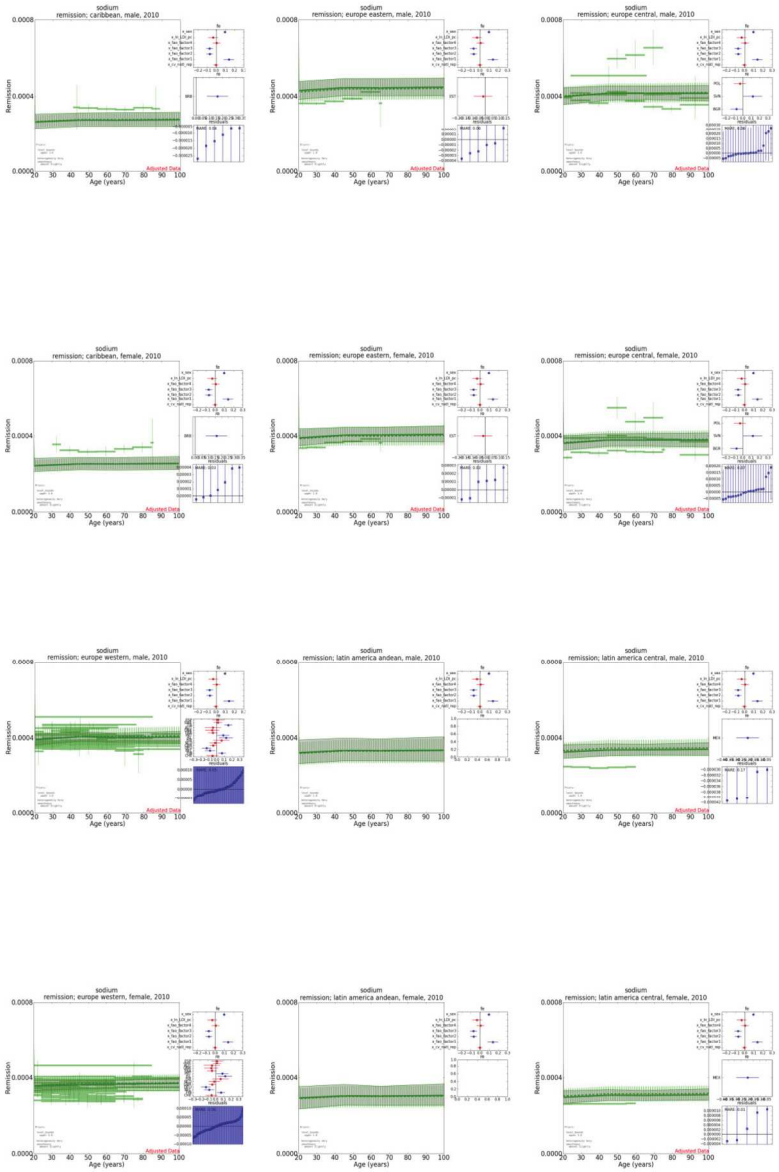

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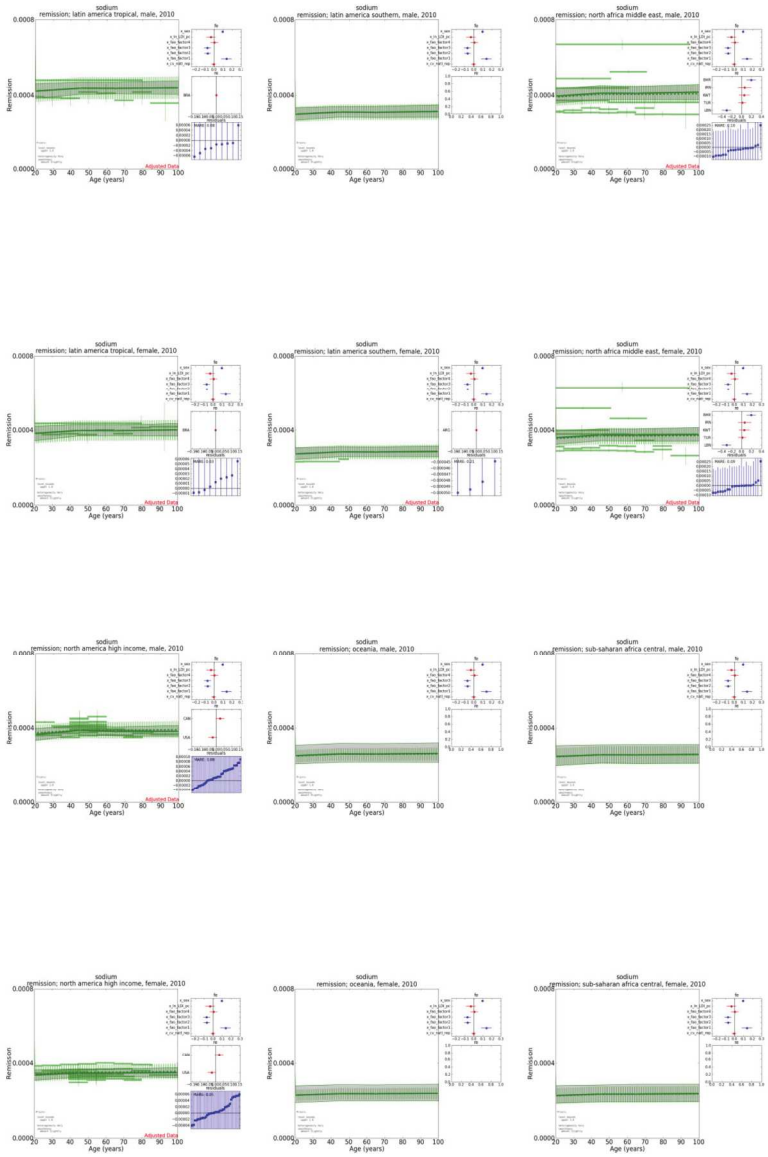

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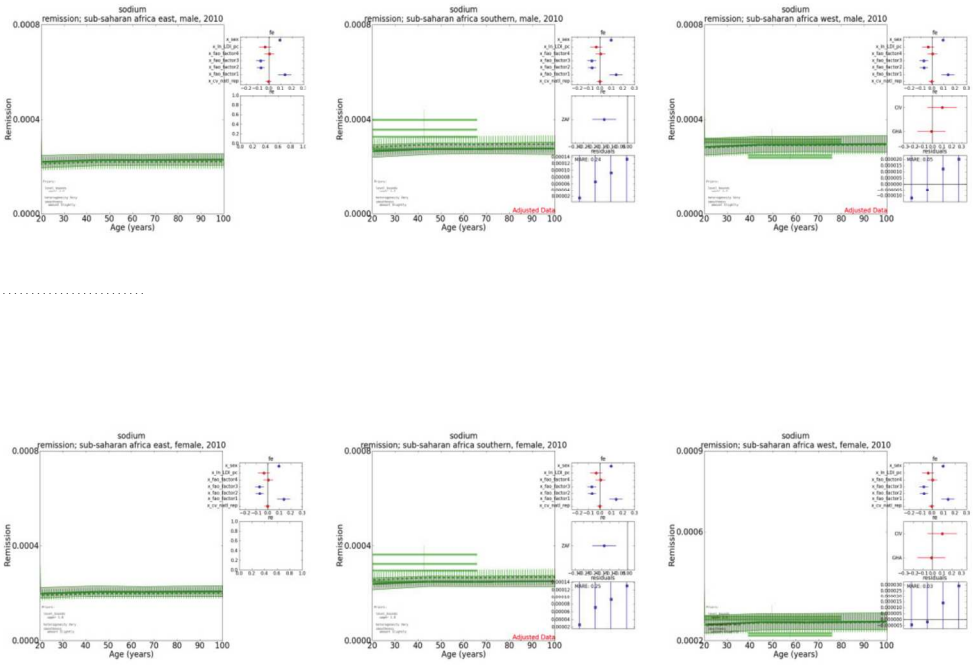

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Global, regional, and national sodium intakes in 1990 and 2010: a systematic analysis of 24-hour urinary sodium excretion and dietary surveys worldwide

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Manuscripts

Global, regional, and national sodium intakes in 1990 and 2010: a systematic analysis of 24-hour urinary sodium excretion and dietary surveys worldwide

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ABSTRACT (300 words)

Objectives

To estimate global, regional (21 regions) and national (187 countries) sodium intakes in adults in 1990 and 2010.

Design

Bayesian hierarchical modeling using all identifiable primary sources.

Data sources and eligibility

We searched and obtained published and unpublished data from 142 surveys of 24-hour urinary sodium and 103 of dietary sodium conducted between 1980 and 2010 across 66 countries. Dietary estimates were converted to urine equivalents based on 79 pairs of dual measurements.

Modeling methods

Bayesian hierarchical modeling used survey data and their characteristics to estimate mean sodium intake, by sex, 5y age group, and associated uncertainty for persons aged 20+ in 187 countries in 1990 and 2010. Country-level covariates were national income per person and composition of food supplies.

Main outcome measures

Mean sodium intake (g/d) as estimable by 24h urine collections, without adjustment for non-urinary losses.

Results

In 2010, global mean sodium intake was 3·95 g/d (95% uncertainty interval: 3·89-4·01). This was nearly twice the WHO recommended limit of 2 g/d and equivalent to 10·06 (9·88-10·21) g/d of salt. Intake in men was ~10% higher than in women; differences by age were small. Intakes were highest in East Asia, Central Asia, and Eastern Europe (mean >4·2 g/d), and in Central Europe and Middle East/North Africa (3·9 to 4·2 g/d). Regional mean intakes in North America, Western Europe, and Australia/New Zealand ranged from 3·4 to 3·8 g/d. Intakes were lower (<3·3 g/d), but more uncertain, in Sub-Saharan Africa and Latin America. Between 1990 and 2010, modest, but uncertain, increases in sodium intakes were identified.

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Conclusion

Sodium intakes exceed recommended levels in almost all countries with small differences by age and sex. Virtually all populations would benefit from sodium reduction, supported by enhanced surveillance.

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Article Summary

Article Focus

1. Because excess sodium intakes raise blood pressure, the leading global risk factor for cardiovascular diseases, knowledge of intake levels provides an important foundation for measures to reduce non-communicable diseases globally.
2. We used Bayesian hierarchical modeling with data from 245 surveys to estimate sodium intakes in adults in 187 countries.

Key messages

1. Mean intake of sodium, globally, was ~4g/d, equivalent to ~10 g/d of salt and about twice the WHO recommended limit of 2 g/d. Variation by age and sex was modest.
2. Intakes varied 2½ fold across 21 global regions, being highest in East and Central Asia and Eastern Europe and lowest in sub-Saharan Africa and Latin America.
3. Virtually all countries would benefit from reduced sodium intakes, supported by enhanced surveillance.

Strengths and limitations of the study

Strengths

1. This is the first study to produce comprehensive and comparable estimates of sodium intake, and their uncertainties, globally.
2. We identified and made use of a much larger set of primary data sources than previous collations.
3. Our Bayesian estimation model used all available data by converting self-reported dietary values to comparable 24 hr urine values and was informed by regional hierarchies and country-level covariates.

Weaknesses

1. In the absence of established conventions for measuring and reporting sodium intakes we have used 24hr urinary excretion, uncorrected for non-renal losses, as a proxy measure. Variation in non-renal (sweat) losses associated with climate or activity levels could introduce additional biases.

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2. Use of biochemical markers to assess and control completeness of urine collections was uncommon impeding adjustment for likely downward biases from incomplete collections.
3. 24h urine collections mostly came from small surveys that were not based on national probability sampling with consequent sampling bias.
4. Primary data was deficient for much of the global population.

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Introduction

Excess sodium intake raises blood pressure (BP),[1 2] a major risk factor for cardiovascular disease,[3 4] and increases risk of stomach cancer,[5 6] a leading fatal cancer globally.[7] Based on established risks across the current range of population intake levels, major international and national agencies have prioritized sodium reduction to decrease the burdens of non-communicable disease.[8–11] Such efforts have been limited, at least in part, by absence of reliable and comparable data on sodium intake for most countries.[12] This has made it difficult to quantify global, regional, or national levels of dietary sodium and the corresponding preventable disease burdens. Changes in national, regional, and global sodium intakes over time are also not well established.

We therefore systematically reviewed and accessed published and unpublished country-specific surveys of sodium intakes from around the world as part of the 2010 Global Burden of Diseases, Injuries, and Risk Factors (GBD) Study. We developed quantitative methods to produce comparable global, regional, and country-specific estimates of sodium intake, by age and sex subgroups, in 1990 and 2010.

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Methods

Study design

We estimated mean sodium intake and its uncertainty by age and sex for 187 countries in 1990 and 2010. Our strategy included 3 steps: (1) systematic searches for data sources from around the world on individual-level sodium intake, including by age and sex subgroups; (2) retrieval of data, including assessment of data quality, representativeness, missingness, and uncertainty, and quantification of measurement comparability across different survey methods; and (3) application of an hierarchical Bayesian estimation model to incorporate missingness, comparability, and sampling and modeling uncertainty to estimate sodium intake by age, sex, country, and time worldwide.

Identification of surveys, access, and extraction

Between Oct 2008 and Nov 2011, we performed systematic searches to identify both urine-based and diet-based surveys (**Figure 1**). The overall search strategy and results have been described.[13 14] Sources for diet-based measurements were primarily national surveys that had incorporated sampling weights, as appropriate. For countries with no national dietary surveys identified, other potential sources were considered, including subnational surveys, household budget survey data, baseline measurements in large cohort studies, the WHO InfoBase, and the STEPS database, published government reports, published sources not previously identified and unpublished data. These searches were complemented by extensive direct contacts with local experts and requests for detailed data.

For urine-based assessments, we searched MEDLINE using the following terms:
((World regions (Mesh)) OR (Name of countries)) AND (salt OR sodium OR Na) AND (intake OR ingest* OR eat* OR consum* OR diet* OR urin* OR excret*)
Limits:Humans, All Adult: 19+ years, Publication Date from 1980/1/1

We also searched for national dietary survey reports and manually searched the reference lists of retrieved articles. We searched publications and web pages of organizations engaged in sodium reduction at national (e.g. UK Food Standards Agency), regional (e.g. European salt reduction program), and international levels (e.g. World Action on Salt and Health) and contacted the nutritional departments of WHO regional offices. Where duplicate sources were

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identified we retained the report with most detail and with most information on the primary metric.

Surveys could be included if they were performed after 1980 and were from a sample that was representative of a national (or if no national survey, a subnational) population; if assessment methods included 24-hour urinary excretion measurements, a diet assessment tool (e.g., diet record, diet recall, food frequency questionnaire [FFQ]), or both; and if there was no evidence suggestive of major selection bias. For example, we excluded studies based exclusively on individuals with hypertension or on pregnant women. Surveys conducted at different locations within a country were counted as different surveys unless they were part of a formal multi-stage sampling design intended to characterize a larger (regional or national) population.

In sum, we identified 142 urine-based surveys and 103 diet-based surveys – with 26 of each forming paired surveys of the same population (**Figure 1 and Table 1**).

Data retrieval and standardization

Because published exposure data were often limited or not in the required format, we obtained data by direct contacts with government officials, scientists, and survey report authors from across the world, who joined our group as Corresponding Members (see list of contributors and **Supplementary Table**). These individuals provided us with either raw data or standardized analyses using an electronic form.[13] Survey characteristics were extracted including date of fieldwork, sampling methods, proportion participating, representativeness, population characteristics, number of subjects by age and sex strata, types and number of measurements (urine, diet including type of dietary tool), validation methods, energy adjustment (for diet-based data), and mean and SD of sodium intake by age and sex groups. To reduce measurement error in dietary estimates by accounting for tendencies to under- or over-report intakes of all foods,[15] dietary data were energy-standardized to 2,000 kilocalories/d (8.37MJ/d). Urinary data were not standardized to energy.

Due to known larger measurement errors in diet-based methods,[16–18] we chose 24-h urinary excretion as our primary metric, and dietary estimates as our secondary metric. We estimated the quantitative relationship between urine and dietary measurements using 79 datapoints from 26 surveys having data on the same individuals in both metrics, and used these results to estimate urinary excretions corresponding to the dietary values in the remaining dietary

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surveys (**Figure 2**). Consequently, our final estimates represent sodium 'intake' using 24-hour urine collections as the reference. We elected not to adjust these final estimates for non-urinary losses (e.g., sweat) because urinary excretion accounts, on average, for ~90% of dietary intake[19–21] and also to enhance comparability with prior estimates of sodium intake (mostly reported as unadjusted 24-h urinary sodium excretion). The possibility that sweat losses vary systematically with climate needs to be clarified by further research. We also did not attempt to adjust these estimates for potential incomplete collections, which are common even in research settings.[22] Thus, our final estimates of dietary intake can be considered conservative estimates of true sodium consumption.

Bayesian hierarchical model

To account for differences in missingness, representativeness, and measurement methods and to incorporate and quantify uncertainty, we specified a Bayesian hierarchical model (using the DisMod-MR model developed as part the Global Burden of Disease Project) to estimate mean sodium intake across the world by sex, age, and country for 2 calendar years – 1990 and 2010. Data from country-specific age and sex subgroups were used simultaneously as inputs, with country, regional, and global random effects. This structure allowed the model to borrow information across countries and regions as necessary, using spatial-temporal regression and Gaussian process regression, while accounting for and quantifying the resulting statistical uncertainties. Representativeness (national with or without probability sampling, subnational) was included as a survey-level covariate. Time-varying country-level covariates further informed the estimates, including lag-distributed national per capita income (inflation and purchasing power parity adjusted[23]) and national dietary patterns characterized by scores on 4 components from a dimension reduction through principal components analysis of 15 diet composition variables from the Food and Agriculture Organization food balance sheets. Because sodium intakes may be non-linearly associated with age, relationships with age were modeled using a cubic spline.

We fitted the Bayesian model with the Markov chain Monte Carlo (MCMC) algorithm and ran 1000 iterations. Posterior distributions of mean sodium intake for each country by age and sex subgroups were obtained, incorporating and reflecting the above sources of uncertainty. Ninety-five percent uncertainty intervals were obtained from the 2.5th and 97.5th percentiles of the posterior distributions.

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Intakes were estimated from the model for 5-year age intervals, by sex for adults aged 20 years or more for each country for 1990 and 2010.. Regional estimates were calculated as population-weighted averages of the constituent country estimates. Intakes for each country, region and time period are reported, both actual intakes (potentially of greater relevance to assessing contributions to local disease burdens) and age standardized intakes[24] (for comparing levels across populations and over time).

Further details on the modeling process and its outputs are provided in the **Methods supplement**.

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Results

Data sources

We identified and obtained data from 245 surveys, including 142 reporting 24-hr urinary sodium data and 103 reporting dietary sodium data, with 26 of each forming urine/diet survey pairs. These surveys were conducted in 66 countries comprising 74% of the global adult population. Sixty one percent (149) of the surveys were conducted in high-income regions and 40% (96) in low- and mid-income regions (**Table** 1 with details for each contributing survey provided in the **Supplementary Table**). East Asia (23 surveys) was the only low- or mid- income region with more than 10 surveys. Counting as a datapoint each estimate for an age-sex stratum, the identified surveys provided 1,346 datapoints (mean: 5.5 per survey), of which 651 were urine-based and 695 were diet-based. More than half (376/651) of the urine-based datapoints came from the Intersalt Study, a major international study with standardized protocols conducted between 1985 and 1987.[25] Fifty datapoints, all in European regions, were from collections biochemically validated for completeness using para-amino benzoic acid (PABA).[26] Ten countries had at least 20 urine-based datapoints, including the USA (86), UK (86), Japan (48), China (41), Italy (33), Belgium (24), Finland (24), Germany (24), New Zealand (22) and Netherlands (20). Urine-based data was relatively scarce in the highest age groups, with only 2 urine-based datapoints for age groups 70+ y; in contrast, 97 diet-based datapoints were available at these older ages.

Global and regional sodium intakes

In 2010 global, mean (95% uncertainty interval) sodium intake in adults was 3.95 (3.89-4.01) g/d, equivalent to salt intakes of 10.06 (9.88-10.21) g/d (based on the assumption, conventional in this context, that all the sodium comes from salt). Globally, mean intake in men was, as expected, higher than that in women: 4.14 (4.04-4.23) versus 3.77 (3.69 – 3.85) g/d, respectively. In every region, sodium intake was lower in women, ranging from 8.9% lower in South Asia to 10.7% lower in Western Europe. Given these consistent, modest differences, additional findings are presented for both sexes combined.

Interestingly, we also identified relatively little variation in sodium intakes by age. Globally, mean intakes rose by ~6% from age 25-29 (3.78 g/d) to age 40-44 (4.04 g/d), and then remained relatively constant thereafter. This pattern was broadly consistent across each of the 21 GBD Study regions (**Figure 3**).

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In contrast to small within-region differences by age or sex, marked differences in intake were identified across regions (**Figures 4 and 5**). Asian regions had highest intakes – East Asia (mean, 95% uncertainty interval) 4.80 (4.59-5.02) g/d, Asia Pacific High Income (mainly Japan and South Korea) 5.00 (4.85-5.16) g/d, and Central Asia 5.51 (5.11-5.95) g/d – corresponding to daily salt intakes of 12.21, 12.71 and 14.01 g, respectively. Very high intakes were also seen in Eastern Europe (4.18 (3.95-4.41) g/d, Central Europe (3.92 (3.73-4.12) g/d, and the Middle East and North Africa (3.92 (3.74-4.12) g/d. Among high-income Western regions, sodium consumption was 3.44 (3.32-3.55) g/d in Australia/New Zealand, 3.62 (3.52-3.72) g/d in the USA/Canada, and 3.81 (3.72-3.91) g/d in Western Europe - equivalent to salt intakes of 8.75, 9.21 and 9.69 g/d, respectively.

Sub-Saharan Africa, Latin America, and the Caribbean and Oceania tended to have lower estimated intakes, but also were based on fewest data sources among all the regions, with resulting larger uncertainties. For example, estimated intakes in Sub-Saharan Africa ranged from 2.18 (2.05-2.32) g/d in Eastern Sub-Saharan Africa to 2.76 (2.58-2.95) g/d in Western Sub-Saharan Africa; and estimated intake in Oceania was 2.48 (2.18–2.80) g/d. Mean intakes were similar or higher in Latin America and the Caribbean, including 2.61 (2.40– 2.83) g/d in the Caribbean, and 3.19 (3.03-3.34) g/d in Central Latin America. Intake in Tropical Latin America (mainly Brazil) was higher than in other Latin American regions and, at 4.11 (4.01–4.22) g/d, exceeded that for US/Canada.

National sodium intakes

We identified substantial variation in estimated sodium intakes across nations (**Figure 6(a), Table 2**). The statistical uncertainty around the estimated intakes for individual countries (**Figure 6(b)**) was larger than that for world regions, especially for countries with no primary data. Thus, relative rankings across different nations should be interpreted in the light of their relative uncertainty levels.

In Western Europe, a region with relatively low uncertainty, estimated mean intakes ranged from 3.28 (2.99-3.59) g/d (Denmark) to 4.43 (4.23-4.62) g/d (Italy). Estimated intakes in the Netherlands, Belgium, Germany and Iceland ranged from 3.33 to 3.59 g/d; in another 12 Western European countries, from 3.62 (3.41-3.86) g/d (Switzerland) to 4.03 (3.78-4.27) g/d (Spain) g/d; and in Cyprus, Luxemburg, Malta, Portugal and Italy, from 4.06 to 4.43 g/d.

Estimated intakes within North Africa/Middle East were also diverse, ranging from 3.13 (2.77–5.54) g/d in Lebanon to 5.37 (4.85-5.92) g/d in Bahrain. In Eastern Sub-Saharan

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Africa, estimated consumption was higher in Mauritius (5.45 [4.57-6.50] g/d) than in other neighboring countries (mean intakes ranging from 1.47 to 4.32 g/d).

In other regions, less variation in sodium intake was identified. For example, sodium consumption was very similar in the USA (3.61 (3.51-3.71) g/d) vs. Canada (3.72 (3.59 – 3.84) g/d). Additionally, relatively small within-region differences were observed in Australia/New Zealand, Eastern Europe, South Asia, and each of the regions of Latin America.

Overall in 2010, estimated mean intakes in 181 of 187 countries, whose total adult population accounted for 99.2% of the world adult population, exceeded the WHO recommendation of 2.00 g/d sodium (~5 g/d salt).[27] In 119 countries (with 88.3% of the world's adult population), estimated mean intakes exceeded this recommended amount by at least 1 g/d; and in 51 countries (44.8% of the world's adult population), estimated mean intakes were more than double this recommended amount.

Changes over time

Globally between 1990 and 2010, modest, statistically non-significant global increases were seen, from 4.02 (3.93-4.11) to 4.14 (4.04-4.23) g/d in males and from 3.63 (3.55–3.71) to 3.77 (3.69–3.85) g/d in females. By region, estimated increases were larger for East Asia, from 4.37 (4.18-4.58) to 4.80 (4.59-5.02) g/d; and Eastern Europe, from 3.76 (3.55-3.97) to 4.18 (3.95-4.41) g/d (for both sexes combined). These estimated increases appeared sensitive to the large proportion of urine-based data in earlier years that was collected in Intersalt (1985-87). When only diet-based data were evaluated, the direction of secular change tended to reverse (data not shown). Thus, estimates of trends over time should be interpreted cautiously. Figure 5 and Table 2 show changes in age-standardised estimates for regions and countries respectively.

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Discussion

Our findings provide systematically assessed and comprehensive evidence on global, regional, and national intake levels and patterns of sodium consumption, including by age and sex. Several findings are notable. Within regions and countries, only small differences were evident comparing younger to older adults or men to women. This suggests relatively constant and common exposures to sodium within populations. On the other hand, marked differences were evident between regions and between countries. Interestingly, these differences were not strongly related to national income, suggesting that in contrast to many other dietary components that are linked to national wealth or affluence, sodium intake is more strongly influenced by other factors. For example, the geographic distribution of highest intakes from East Asia to Eastern and Central Europe suggests a "Silk Road" pattern, implying shared retentions from past transportation and food cultures such as use of salt for food preservation.[28]

A recent Institute of Medicine committee concluded that, based only on studies of the association between sodium intake and incidence of clinical events (i.e. ignoring effects on blood pressure), evidence was insufficient to conclusively choose between modest (e.g., 2.3 g/d) vs. low (e.g., 1.5 g/d) sodium intakes as long term targets for populations.[29] The resulting controversy over this somewhat narrowly-based judgment overshadowed their other main conclusion that, considered collectively, the evidence indicated a positive relationship between high sodium intakes and cardiovascular events and was consistent with BP-raising effects of dietary sodium. Numerous other organizations have systematically reviewed the evidence and concluded that intakes of sodium above levels variously specified in the range 1.2 to 2.4 g/d increase cardiovascular risk.[11 27 30] Thus, whereas identified optimal target intakes have varied from 1.20 to 2.4 g/d,[27 30 31] all have consistently concluded that sodium intakes above these levels are adverse for health. Our findings demonstrate that, whether modest (2 to 2.4 g/d) or low (1.20 to 1.5 g/d) target intakes are designated as optimal, virtually every nation in the world, and each age and sex group within these nations, exceed these optimal intakes.

The Intersalt study provided the first extensive body of comparable urine based data on sodium consumption globally, with results from 52 surveys in 30 countries

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reported in 1988 and 1989.[32] In 2009, Brown and colleagues produced a tabular update of 11 diet-based and 26 urine-based surveys published after Intersalt.[12] We are not aware of any other reports that have estimated national sodium intake levels globally.

Strengths and innovations of our investigation can also be highlighted. We systematically identified and extracted data from around the world on both urinary and dietary sodium, including many sources of previously unavailable data. We evaluated and incorporated the evidence for systematic differences between urinary and dietary estimates, increasing comparability and allowing us to draw on the different strengths of each. In contrast with diet based surveys many of which were based on national probability samples, urine-based surveys were often of smaller size and representative only of local populations. . Our model takes advantage of all available raw data in the world; a cross-walk to render self-reported dietary values more comparable to 24-hr urine values, based on empirical relations between these measures; and then the relation between these data and global country-level covariates (GDP, age, sex, FAO factor analysis) in a Bayesian hierarchical fashion.

Potential limitations should be considered. Primary data sources were limited or missing in many countries. Our model dealt with this by 'borrowing' information within and across countries, regions, and time, based on both country-level and survey-level covariates; it also incorporated both missingness and types of available data to quantify the final uncertainty. For regions and their constituent countries where primary exposure data is limited or absent (e.g. Sub-Saharan Africa, central and Latin America, Andean), relative uncertainty is correspondingly greater: their Monte Carlo standard errors exceed 9% their means, compared to 2.5% for the relatively data rich region of Western Europe. For data deficient regions final estimates correspond to their priors, which depend in turn on spatio-temporal 'borrowing' and on the use of covariates. Model outputs for such regions (Figures S1, S3, S4) show that the coefficients for the fixed effects of the FAO diet composition components (especially component 1) are larger than the coefficients on income (which were expected to be low). The assumption of our Bayesian approach is that the final estimations, informed by both the raw data, covariates, and regional hierarchy, are closer to the 'truth' than any isolated datapoint. Substantial reduction of the uncertainty in the estimates for data deficient regions and countries must await the carrying out of good quality

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national surveillance studies so that the dependence of final estimates on priors, and their associated uncertainties, is reduced.

We had more limited data across time to quantify temporal trends in intakes. In addition, our analysis evaluated intakes in 1990 and 2010, which does not exclude larger changes over a broader time horizon. For instance, reported intakes in Japan[33] Portugal[34] and Finland[35] from several decades ago were much higher than our recent estimates. This implies potentially large reductions in sodium intakes in these countries over time frames longer than covered in our study, consistent with changes in traditional methods of food preservation made possible by widespread refrigeration.[36] Conversely, more recent increased global consumption of highly processed foods [37] may be countering or even reversing these historical associations between modernization and declining sodium intakes.

In May 2013, the 66th World Health Assembly followed up the 2011 United Nations High-Level Summit on the Prevention and Control of Non-Communicable Diseases with a resolution endorsing a global action plan that included a proposed 30% reduction in salt/sodium intake.[38] Our findings can help inform the planning and design of such high priority programs. Optimal strategies for reducing sodium will partly depend on the proportion of dietary sodium derived from cooking or table salt (e.g., relatively high in Asian nations) vs. from prepared or industrialized foods (e.g., the majority in high-income Western nations).[12] In a limited number of high-income countries, sustained, coordinated public health programs have helped lower sodium intakes, for example in Japan,[39] Finland[35] and the UK[40]. The most recent surveillance data from the UK (too late for inclusion in our model) documents a 15% reduction in mean sodium intakes over the preceding decade, coinciding with a coordinated national program which includes formal food industry commitments.[41] Media and educational programs can also have an impact in countries where substantial proportions of dietary sodium are added during household food preparation and at the table.[42] Simulations suggest that population-wide sodium reduction strategies would be not only cost-effective, but could be cost-saving.[43–45] While the food industry often cites taste as a major barrier to sodium reduction, our findings provide empiric evidence on the remarkable adaptability of the human palate to preference for salt,[46] with usual sodium intakes varying more than 2.5-fold across world regions and 4-fold across nations.

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Our results also highlight data gaps and the need for improved surveillance of sodium intakes using transparent, validated and comparable methods. If a gold standard were specified for the national surveillance of sodium intakes it would likely entail the combination of repeated national probability sampling and the use of 24 hour urine collections biochemically validated for completeness. [22 41] To our knowledge, only the UK has implemented such a system.. Yet, despite the limitations of the primary data sources available to us, our estimates of mean intakes, interpreted in conjunction with their uncertainties indicate that, for virtually all countries, it is likely to be some time before mean intakes approach levels at which the benefits of further reduction may be uncertain.[29] Thus, the remaining uncertainties highlighted by our work inform the need both for enhanced surveillance and for further research but do not alter the imperative for strong, active public health policies to reduce national sodium intakes from their current levels.

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Authorship

The first two authors contributed equally to the paper. The following are members of the Global Burden of Diseases Nutrition and Chronic Diseases Expert Group (NutriCoDE) core group: Dariush Mozaffarian (USA), Majid Ezzati (UK), Saman Fahimi (USA), Shahab Khatibzadeh (USA), Renata Micha (Greece), John Powles (UK), Peilin Shi (USA).

Contributorship statement

Summary version

ME, JP and DM conceived and designed the study. DM obtained funding. SF, RM, SK and PS designed and carried out the data collection, extraction and coding. SSL and REE designed and carried out the statistical modelling with help from all co-authors. JP and DM drafted the paper which was critically reviewed by all other co-authors. JP and DM had full access to all the data, take full responsibility for its integrity and are guarantors for the paper.

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Competing interests

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Data sharing statement

No additional data available.

Contributorship Statement

John Powles: Study concept and design; data collection; data analysis; interpretation of data; drafting of the manuscript; critical revision of the manuscript for important intellectual content.
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FIGURE LEGENDS

Figure 1. Search strategies for global sodium exposure data: urine-based (left) and diet-based (right)

[Footnote] The black dashed lines show dietary Na assessment studies that were identified through the search for 24-hour urinary sodium excretion studies.

Figure 2. Relationship between measured urinary sodium and measured dietary sodium in 79 age/sex strata from 26 survey pairs

[Footnote] The solid line represents the cross-walk regression line (linear regression of log-transformed urinary sodium on log-transformed dietary sodium); and the dotted lines, the 95% uncertainty intervals. With the partial exception of 8 age and sex strata (all from 2 of the 3 InterMap study sites in China) in which urinary sodium levels were systematically higher relative to their dietary levels, good agreement was seen between the two metrics. The regression co-efficients obtained from this analysis informed the Bayesian hierarchical model of the relationship between the two metrics. Adding a term to identify the survey sites generating the outlying points increased the r^2 to 0.79 but it was not retained because this term did not correspond to a generic survey characteristic that could be used in predictions outside the cross-walk dataset. The wider uncertainty bounds for the modeled relationship in the upper part of its range reflect the influence of the outliers.

Figure 3. Sodium intakes in g/d by age, for regions and globally, both sexes combined, 2010

Figure 4. Mean (95% uncertainty interval) sodium intakes (g/d) in 2010 in 21 GBD regions

[Footnote] Regions are ranked by levels in both sexes combined, ages 20+. Intakes are not age-standardised.

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Figure 5. Mean (95% uncertainty interval) age-standardised sodium intakes (g/d) in 1990 and 2010 in 21 GBD regions

[Footnote] The upper symbol for each pair is for 2010. Regions are ranked by levels in both sexes combined, ages 20+.

Figure 6. Sodium intakes by country, for ages 20+, average of both sexes, in 2010. Panel (a) presents mean intakes in g/d; panel (b) presents relative uncertainty*

[Footnote] *Monte Carlo standard errors divided by the mean of these intake estimates.

Supplementary Materials

Methods Supplement: The estimation model, DisMod-MR

With associated figures

Figure S1. Guide to model outputs for regions

Figure S2. Model output for regions (1)

Figure S3. Model output for regions (2)

Figure S4. Model output for regions (3)

Figure S5. Model output for regions (4)

Supplementary Table. Surveys and survey pairs used in the assessment of sodium exposure with identification of sources for published reports and of corresponding members where data was provided on request.

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Table 1. Classification of 245 surveys of sodium intake by exposure metric reported, period of survey and national representativeness, with pairs of surveys reporting in both metrics identified.

	Surveys (n=245)		Survey characteristics (n=219 counting survey pairs as 1)						
			Contributing surveys and survey pairs by metric				Period		
GBD Region (*=high income)	Urine-based	Diet-based	Urine-based only	Diet-based only	Both (survey pairs)[†]	Total	1980-1998	1999-2010	Nationally represent-ative
Asia, Central	1	0	1	0	0	1	1	0	1 (100%)
Asia, East	11	15	8	12	3	23	21	2	3 (13%)
Asia Pacific High Income*	12	11	7	5	6	18	14	4	4 (22%)
Asia, South	2	4	2	4	0	6	3	3	0 (0%)
Asia, Southeast	2	3	2	3	0	5	2	3	2 (40%)
Australasia*	8	1	8	1	0	9	6	3	1 (11%)
Caribbean	5	2	5	2	0	7	6	1	2 (29%)
Europe, Central	4	2	4	2	0	6	2	4	3 (50%)
Europe, Eastern	1	1	1	1	0	2	2	0	1 (50%)
Europe, Western*	51	31	46	27	4	77	45	32	27 (35%)
Latin America, Andean	0	0	0	0	0	0	0	0	NA
Latin America, Central	3	1	3	1	0	4	3	1	1 (25%)
Latin America, Southern	1	1	1	1	0	2	1	1	1 (50%)
Latin America, Tropical	0	2	0	2	0	2	0	2	1 (50%)
North America, High Income*	21	14	11	4	10	25	20	5	4 (16%)
North Africa Middle East	2	7	2	7	0	9	2	7	4 (44%)
Oceania	1	2	1	2	0	3	3	0	3 (100%)
Sub-Saharan Africa, East	3	2	3	2	0	5	5	0	0 (0%)
Sub-Saharan Africa, Central	0	0	0	0	0	0	0	0	NA
Sub-Saharan Africa, Southern	7	4	4	1	3	8	4	4	1 (13%)
Sub-Saharan Africa, West	7	0	7	0	0	7	5	2	0 (0%)
Total	142	103	116	77	26[†]	219	145	74	55 (35%[‡])

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[†] These 26 surveys with measurements in both metrics reported on all subjects provided the 79 paired urine-diet datapoints that were used to estimate the relationship between the 2 metrics (Figure 2); the diet-based datapoints from these 26 surveys were not subsequently used in the final estimation model.

[‡] Unweighted mean for 19 regions with at least 1 survey

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Table 2. Age-standardised estimated sodium intakes (g/d) in 1990 and 2010, persons aged 20 and over, by country (95% uncertainty intervals).

	Total		Males		Females	
	1990	2010	1990	2010	1990	2010
Afghanistan	3.29 (2.71-3.95)	3.39 (2.79-4.06)	3.44 (2.61-4.46)	3.55 (2.63-4.69)	3.12 (2.36-4.06)	3.22 (2.42-4.17)
Albania	3.47 (2.89-4.16)	3.67 (3.05-4.34)	3.64 (2.83-4.62)	3.86 (2.98-5.00)	3.31 (2.56-4.29)	3.48 (2.67-4.37)
Algeria	3.91 (3.32-4.59)	4.28 (3.59-5.00)	4.09 (3.19-5.17)	4.51 (3.50-5.72)	3.73 (2.97-4.74)	4.07 (3.20-5.08)
Andorra	3.56 (3.04-4.16)	3.81 (3.21-4.44)	3.85 (3.05-4.83)	4.01 (3.19-5.07)	3.29 (2.59-4.05)	3.61 (2.84-4.53)
Angola	2.46 (2.07-2.90)	2.49 (2.06-2.97)	2.58 (2.03-3.28)	2.61 (2.02-3.35)	2.35 (1.82-2.94)	2.38 (1.86-3.07)
Antigua and Barbuda	2.71 (2.28-3.23)	2.67 (2.23-3.18)	2.85 (2.19-3.64)	2.81 (2.18-3.55)	2.58 (2.01-3.26)	2.54 (1.98-3.24)
Argentina	3.01 (2.93-3.10)	3.00 (2.92-3.08)	3.16 (3.03-3.29)	3.15 (3.03-3.26)	2.87 (2.76-2.99)	2.87 (2.76-2.98)
Armenia	4.84 (4.04-5.67)	4.92 (4.13-5.77)	5.07 (4.03-6.31)	5.19 (4.06-6.57)	4.65 (3.64-5.86)	4.71 (3.69-5.89)
Australia	3.38 (3.26-3.50)	3.42 (3.29-3.55)	3.55 (3.37-3.75)	3.59 (3.39-3.77)	3.22 (3.05-3.40)	3.26 (3.09-3.42)
Austria	3.89 (3.57-4.22)	3.95 (3.63-4.31)	4.20 (3.73-4.73)	4.16 (3.70-4.64)	3.60 (3.22-4.06)	3.76 (3.29-4.28)
Azerbaijan	4.55 (3.83-5.34)	5.06 (4.31-5.98)	4.79 (3.74-6.08)	5.31 (4.18-6.71)	4.35 (3.44-5.56)	4.85 (3.83-6.13)
Bahamas	3.03 (2.53-3.60)	2.99 (2.48-3.54)	3.18 (2.41-4.10)	3.13 (2.41-3.97)	2.89 (2.24-3.65)	2.86 (2.22-3.67)
Bahrain	4.40 (4.03-4.82)	5.38 (4.85-5.91)	4.56 (4.05-5.11)	5.57 (4.88-6.31)	4.15 (3.68-4.69)	5.05 (4.42-5.72)
Bangladesh	3.68 (3.09-4.41)	3.54 (2.98-4.21)	3.84 (3.02-4.93)	3.71 (2.89-4.67)	3.51 (2.76-4.41)	3.38 (2.63-4.32)
Barbados	3.40 (3.12-3.69)	3.42 (3.11-3.76)	3.56 (3.17-3.99)	3.59 (3.12-4.09)	3.25 (2.87-3.65)	3.25 (2.85-3.69)
Belarus	4.00 (3.39-4.72)	4.35 (3.69-5.16)	4.19 (3.28-5.22)	4.55 (3.55-5.69)	3.83 (2.98-4.72)	4.17 (3.27-5.24)
Belgium	3.48 (3.30-3.67)	3.45 (3.23-3.68)	3.76 (3.48-4.05)	3.64 (3.32-3.96)	3.21 (2.98-3.46)	3.27 (2.98-3.60)
Belize	2.67 (2.38-3.02)	2.62 (2.34-2.93)	2.80 (2.38-3.29)	2.75 (2.31-3.21)	2.55 (2.17-3.01)	2.50 (2.10-2.93)
Benin	2.86 (2.53-3.28)	2.85 (2.49-3.22)	3.01 (2.50-3.57)	2.97 (2.47-3.52)	2.73 (2.27-3.26)	2.73 (2.28-3.25)
Bhutan	3.72 (3.13-4.33)	3.64 (3.07-4.24)	3.88 (3.05-4.86)	3.80 (2.97-4.78)	3.55 (2.82-4.46)	3.45 (2.74-4.26)
Bolivia, Plurinational State of	3.51 (2.97-4.11)	3.59 (3.02-4.20)	3.67 (2.90-4.54)	3.77 (3.01-4.69)	3.35 (2.63-4.16)	3.41 (2.71-4.30)
Bosnia and Herzegovina	3.26 (2.71-3.93)	3.46 (2.88-4.15)	3.43 (2.62-4.41)	3.62 (2.78-4.59)	3.10 (2.38-4.07)	3.32 (2.58-4.25)
Botswana	2.49 (2.07-2.95)	2.53 (2.15-2.97)	2.63 (2.05-3.33)	2.66 (2.06-3.30)	2.37 (1.85-2.97)	2.40 (1.90-3.00)
Brazil	3.89 (3.78-3.99)	4.11 (4.01-4.22)	4.08 (3.93-4.23)	4.31 (4.17-4.46)	3.70 (3.57-3.83)	3.92 (3.79-4.07)
Brunei Darussalam	4.40 (3.70-5.13)	4.42 (3.71-5.16)	4.59 (3.62-5.73)	4.62 (3.59-5.83)	4.18 (3.27-5.24)	4.21 (3.27-5.30)
Bulgaria	3.63 (3.40-3.85)	3.62 (3.39-3.87)	3.82 (3.48-4.17)	3.80 (3.45-4.18)	3.45 (3.14-3.78)	3.45 (3.13-3.79)
Burkina Faso	2.91 (2.46-3.46)	2.88 (2.40-3.41)	3.07 (2.41-3.91)	3.04 (2.38-3.80)	2.77 (2.15-3.53)	2.74 (2.11-3.47)
Burundi	1.62 (1.31-1.99)	1.73 (1.42-2.09)	1.70 (1.25-2.26)	1.82 (1.38-2.36)	1.56 (1.14-2.07)	1.65 (1.23-2.15)
Cambodia	4.54 (3.81-5.38)	4.41 (3.73-5.18)	4.76 (3.69-6.07)	4.65 (3.68-5.87)	4.37 (3.41-5.52)	4.20 (3.26-5.24)
Cameroon	2.07 (1.82-2.35)	2.09 (1.84-2.36)	2.18 (1.81-2.59)	2.19 (1.81-2.58)	1.97 (1.64-2.32)	1.99 (1.68-2.38)

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Canada	3.55 (3.45-3.66)	3.71 (3.58-3.83)	3.74 (3.58-3.90)	3.88 (3.69-4.08)	3.37 (3.22-3.52)	3.53 (3.36-3.70)
Cape Verde	2.99 (2.55-3.51)	3.25 (2.74-3.89)	3.16 (2.47-3.92)	3.42 (2.63-4.33)	2.87 (2.21-3.63)	3.10 (2.39-3.86)
Central African Republic	2.75 (2.32-3.25)	2.80 (2.33-3.29)	2.89 (2.24-3.62)	2.94 (2.30-3.71)	2.62 (2.06-3.27)	2.66 (2.05-3.37)
Chad	2.87 (2.42-3.38)	2.87 (2.43-3.37)	3.00 (2.33-3.78)	3.02 (2.37-3.76)	2.74 (2.12-3.38)	2.72 (2.15-3.39)
Chile	2.79 (2.38-3.29)	2.80 (2.35-3.31)	2.92 (2.30-3.74)	2.92 (2.29-3.70)	2.67 (2.11-3.37)	2.69 (2.13-3.36)
China	4.42 (4.24-4.63)	4.83 (4.62-5.05)	4.63 (4.35-4.93)	5.05 (4.71-5.39)	4.20 (3.94-4.49)	4.60 (4.31-4.88)
Colombia	4.12 (3.77-4.45)	4.09 (3.77-4.43)	4.31 (3.82-4.83)	4.29 (3.83-4.81)	3.93 (3.50-4.43)	3.91 (3.48-4.36)
Comoros	1.69 (1.42-2.02)	1.67 (1.41-1.98)	1.78 (1.39-2.26)	1.74 (1.35-2.22)	1.61 (1.22-2.04)	1.59 (1.24-2.03)
Congo	2.30 (1.95-2.70)	2.25 (1.88-2.67)	2.42 (1.89-3.05)	2.35 (1.83-2.97)	2.18 (1.69-2.73)	2.15 (1.63-2.78)
Congo, the Democratic Republic of the	2.27 (1.90-2.66)	2.42 (2.05-2.84)	2.39 (1.84-2.95)	2.54 (1.97-3.24)	2.16 (1.68-2.74)	2.31 (1.82-2.90)
Costa Rica	2.98 (2.51-3.50)	3.18 (2.71-3.73)	3.13 (2.49-3.91)	3.32 (2.56-4.18)	2.83 (2.20-3.56)	3.03 (2.40-3.76)
Côte dIvoire	2.78 (2.48-3.13)	2.80 (2.50-3.13)	2.90 (2.45-3.42)	2.94 (2.48-3.45)	2.64 (2.22-3.11)	2.65 (2.25-3.11)
Croatia	3.25 (2.73-3.81)	3.71 (3.15-4.34)	3.42 (2.70-4.28)	3.88 (3.04-4.80)	3.10 (2.44-3.92)	3.54 (2.80-4.45)
Cuba	2.80 (2.36-3.29)	2.64 (2.23-3.12)	2.94 (2.32-3.67)	2.75 (2.16-3.46)	2.66 (2.07-3.27)	2.52 (1.99-3.21)
Cyprus	3.76 (3.17-4.45)	4.06 (3.41-4.76)	4.05 (3.18-5.12)	4.29 (3.26-5.36)	3.49 (2.71-4.39)	3.83 (3.03-4.81)
Czech Republic	3.74 (3.16-4.44)	3.98 (3.37-4.74)	3.97 (3.14-5.02)	4.17 (3.31-5.31)	3.53 (2.75-4.36)	3.80 (3.00-4.75)
Denmark	3.53 (3.23-3.82)	3.27 (2.98-3.58)	3.80 (3.36-4.29)	3.43 (3.00-3.88)	3.26 (2.87-3.67)	3.11 (2.72-3.55)
Djibouti	2.29 (1.90-2.72)	2.36 (1.94-2.81)	2.39 (1.85-3.07)	2.48 (1.91-3.14)	2.19 (1.67-2.81)	2.24 (1.74-2.84)
Dominica	2.62 (2.21-3.10)	2.69 (2.30-3.20)	2.74 (2.14-3.44)	2.82 (2.13-3.60)	2.51 (1.96-3.22)	2.57 (1.96-3.29)
Dominican Republic	2.45 (2.08-2.85)	2.60 (2.21-3.03)	2.57 (2.01-3.26)	2.70 (2.14-3.38)	2.32 (1.83-2.86)	2.50 (1.99-3.12)
Ecuador	2.88 (2.41-3.38)	3.03 (2.55-3.57)	3.00 (2.37-3.76)	3.17 (2.47-4.01)	2.76 (2.16-3.45)	2.88 (2.29-3.66)
Egypt	3.63 (3.10-4.22)	3.68 (3.13-4.32)	3.81 (3.01-4.75)	3.85 (3.00-4.82)	3.45 (2.75-4.33)	3.52 (2.77-4.36)
El Salvador	3.19 (2.64-3.79)	3.19 (2.71-3.71)	3.35 (2.60-4.28)	3.36 (2.63-4.22)	3.04 (2.37-3.85)	3.05 (2.39-3.81)
Equatorial Guinea	2.50 (2.12-3.00)	2.30 (1.90-2.78)	2.61 (2.07-3.24)	2.40 (1.80-3.08)	2.37 (1.89-3.04)	2.20 (1.67-2.90)
Eritrea	2.32 (1.93-2.73)	2.37 (2.00-2.82)	2.43 (1.88-3.11)	2.50 (1.96-3.18)	2.22 (1.71-2.78)	2.25 (1.76-2.83)
Estonia	3.49 (3.30-3.69)	3.95 (3.69-4.23)	3.67 (3.40-3.96)	4.15 (3.76-4.56)	3.33 (3.07-3.60)	3.77 (3.43-4.16)
Ethiopia	2.30 (1.92-2.70)	2.27 (1.95-2.67)	2.42 (1.87-3.07)	2.38 (1.87-2.97)	2.19 (1.72-2.74)	2.17 (1.72-2.71)
Fiji	2.86 (2.41-3.35)	2.87 (2.41-3.41)	2.99 (2.34-3.76)	3.01 (2.36-3.84)	2.73 (2.16-3.42)	2.74 (2.13-3.43)
Finland	3.73 (3.52-3.95)	3.85 (3.63-4.07)	4.02 (3.70-4.39)	4.05 (3.72-4.40)	3.44 (3.16-3.74)	3.65 (3.35-3.94)
France	3.70 (3.52-3.91)	3.77 (3.58-3.97)	4.00 (3.72-4.30)	3.96 (3.66-4.28)	3.41 (3.17-3.65)	3.58 (3.31-3.86)
Gabon	1.93 (1.58-2.36)	2.01 (1.63-2.45)	2.02 (1.53-2.62)	2.09 (1.55-2.76)	1.83 (1.39-2.35)	1.92 (1.42-2.54)
Gambia	3.04 (2.58-3.61)	3.07 (2.59-3.58)	3.18 (2.51-4.05)	3.22 (2.56-4.06)	2.88 (2.24-3.63)	2.93 (2.27-3.73)
Georgia	4.73 (3.95-5.60)	5.30 (4.49-6.26)	4.95 (3.94-6.29)	5.57 (4.44-7.03)	4.53 (3.55-5.72)	5.07 (3.96-6.29)
Germany	3.45 (3.24-3.68)	3.54 (3.36-3.73)	3.73 (3.42-4.07)	3.72 (3.43-4.02)	3.18 (2.91-3.47)	3.36 (3.13-3.61)
Ghana	2.44 (2.19-2.73)	2.35 (2.09-2.61)	2.56 (2.19-2.98)	2.45 (2.09-2.88)	2.32 (2.02-2.71)	2.24 (1.89-2.62)
Greece	3.55 (2.92-4.25)	3.77 (3.16-4.52)	3.82 (2.92-4.91)	3.97 (3.11-5.03)	3.29 (2.53-4.27)	3.58 (2.76-4.53)

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Grenada	2.44 (2.07-2.85)	2.61 (2.20-3.09)	2.55 (2.02-3.21)	2.73 (2.14-3.48)	2.33 (1.83-2.91)	2.48 (1.92-3.18)
Guatemala	2.86 (2.52-3.22)	2.94 (2.60-3.28)	2.99 (2.50-3.53)	3.08 (2.59-3.63)	2.73 (2.31-3.19)	2.81 (2.38-3.29)
Guinea	2.71 (2.29-3.22)	2.77 (2.33-3.26)	2.84 (2.23-3.58)	2.92 (2.30-3.64)	2.59 (2.04-3.27)	2.62 (2.06-3.25)
Guinea-Bissau	2.94 (2.48-3.48)	3.03 (2.55-3.61)	3.09 (2.44-3.87)	3.17 (2.49-4.09)	2.80 (2.23-3.50)	2.90 (2.25-3.66)
Guyana	2.36 (1.98-2.78)	2.45 (2.05-2.93)	2.47 (1.91-3.14)	2.56 (2.02-3.30)	2.26 (1.78-2.88)	2.34 (1.82-2.98)
Haiti	2.43 (2.02-2.86)	2.66 (2.23-3.15)	2.56 (2.00-3.14)	2.78 (2.17-3.50)	2.31 (1.79-2.94)	2.54 (1.98-3.26)
Honduras	2.88 (2.42-3.41)	2.95 (2.49-3.48)	3.02 (2.40-3.75)	3.07 (2.38-3.88)	2.75 (2.11-3.49)	2.84 (2.24-3.55)
Hungary	4.28 (3.90-4.67)	4.23 (3.87-4.57)	4.50 (3.94-5.13)	4.43 (3.91-4.95)	4.07 (3.57-4.62)	4.04 (3.60-4.50)
Iceland	3.53 (3.15-3.90)	3.58 (3.24-3.97)	3.79 (3.23-4.33)	3.77 (3.22-4.34)	3.25 (2.78-3.78)	3.38 (2.92-3.90)
India	3.78 (3.69-3.87)	3.72 (3.63-3.82)	3.95 (3.82-4.07)	3.88 (3.73-4.02)	3.61 (3.49-3.73)	3.56 (3.44-3.68)
Indonesia	3.43 (3.07-3.82)	3.36 (3.02-3.76)	3.59 (3.09-4.18)	3.53 (3.02-4.09)	3.28 (2.82-3.81)	3.21 (2.77-3.75)
Iran, Islamic Republic of	3.85 (3.46-4.27)	4.02 (3.64-4.44)	4.03 (3.46-4.64)	4.21 (3.65-4.85)	3.67 (3.17-4.20)	3.83 (3.33-4.37)
Iraq	3.46 (2.94-4.09)	3.76 (3.19-4.46)	3.64 (2.86-4.61)	3.95 (3.12-5.00)	3.30 (2.63-4.18)	3.59 (2.85-4.51)
Ireland	3.61 (3.24-4.06)	3.74 (3.35-4.18)	3.91 (3.35-4.57)	3.93 (3.38-4.58)	3.32 (2.84-3.85)	3.55 (3.01-4.14)
Israel	3.68 (3.20-4.17)	3.79 (3.27-4.37)	3.97 (3.21-4.81)	4.00 (3.20-4.91)	3.40 (2.79-4.08)	3.59 (2.91-4.32)
Italy	4.31 (4.11-4.51)	4.42 (4.22-4.61)	4.65 (4.30-4.98)	4.65 (4.34-4.96)	3.99 (3.72-4.26)	4.19 (3.92-4.45)
Jamaica	1.90 (1.76-2.06)	1.92 (1.77-2.08)	2.00 (1.81-2.22)	2.01 (1.79-2.26)	1.82 (1.63-2.03)	1.84 (1.63-2.06)
Japan	4.71 (4.54-4.89)	4.89 (4.71-5.08)	4.93 (4.67-5.19)	5.12 (4.85-5.41)	4.50 (4.27-4.75)	4.68 (4.43-4.93)
Jordan	3.54 (3.00-4.19)	4.13 (3.47-4.87)	3.69 (2.93-4.62)	4.31 (3.41-5.48)	3.38 (2.67-4.19)	3.95 (3.04-5.00)
Kazakhstan	4.92 (4.17-5.74)	5.98 (5.07-7.14)	5.16 (4.07-6.41)	6.31 (4.95-7.98)	4.72 (3.66-5.84)	5.70 (4.47-7.21)
Kenya	1.43 (1.30-1.58)	1.48 (1.34-1.62)	1.50 (1.29-1.71)	1.55 (1.34-1.77)	1.37 (1.19-1.58)	1.41 (1.22-1.60)
Kiribati	2.18 (1.80-2.65)	2.22 (1.82-2.68)	2.27 (1.72-2.97)	2.31 (1.72-3.05)	2.07 (1.59-2.70)	2.14 (1.60-2.79)
Korea, Democratic People's Republic of	3.34 (2.75-3.95)	3.79 (3.16-4.46)	3.49 (2.70-4.39)	4.01 (3.07-5.21)	3.20 (2.46-4.03)	3.59 (2.79-4.55)
Korea, Republic of	4.92 (4.68-5.17)	5.21 (4.98-5.48)	5.15 (4.79-5.52)	5.46 (5.12-5.81)	4.70 (4.39-5.04)	4.98 (4.66-5.32)
Kuwait	3.66 (3.31-4.05)	3.88 (3.46-4.31)	3.81 (3.32-4.36)	4.01 (3.45-4.60)	3.46 (3.02-3.95)	3.65 (3.13-4.19)
Kyrgyzstan	5.09 (4.29-5.98)	5.38 (4.55-6.32)	5.34 (4.30-6.64)	5.64 (4.43-7.12)	4.88 (3.79-6.04)	5.14 (4.08-6.41)
Lao Peoples Democratic Republic	4.58 (3.80-5.44)	4.45 (3.75-5.27)	4.78 (3.83-6.02)	4.69 (3.63-5.98)	4.39 (3.43-5.53)	4.23 (3.31-5.36)
Latvia	3.58 (3.03-4.24)	4.19 (3.57-5.01)	3.75 (2.97-4.74)	4.37 (3.41-5.45)	3.43 (2.74-4.30)	4.02 (3.20-5.08)
Lebanon	2.60 (2.34-2.88)	3.13 (2.78-3.54)	2.72 (2.32-3.15)	3.30 (2.75-3.89)	2.50 (2.13-2.91)	2.98 (2.49-3.52)
Lesotho	2.66 (2.18-3.14)	2.62 (2.21-3.11)	2.79 (2.13-3.56)	2.76 (2.16-3.49)	2.55 (1.94-3.23)	2.50 (1.92-3.18)
Liberia	2.64 (2.23-3.14)	2.68 (2.23-3.17)	2.76 (2.12-3.49)	2.82 (2.20-3.60)	2.52 (2.01-3.17)	2.55 (1.96-3.26)
Libyan Arab Jamahiriya	3.74 (3.14-4.45)	4.24 (3.55-5.01)	3.90 (3.06-4.97)	4.45 (3.50-5.60)	3.54 (2.76-4.50)	4.03 (3.15-5.08)
Lithuania	3.60 (3.04-4.27)	4.07 (3.47-4.74)	3.77 (3.00-4.64)	4.27 (3.44-5.38)	3.45 (2.73-4.34)	3.90 (3.06-4.79)
Luxembourg	3.87 (3.29-4.56)	4.07 (3.42-4.82)	4.18 (3.27-5.20)	4.28 (3.36-5.37)	3.57 (2.81-4.60)	3.85 (2.99-4.88)
Macedonia, the former Yugoslav Republic of	3.30 (2.77-3.90)	3.91 (3.31-4.55)	3.48 (2.75-4.47)	4.10 (3.21-5.09)	3.13 (2.47-3.98)	3.72 (2.93-4.64)
Madagascar	2.15 (1.83-2.59)	2.20 (1.85-2.58)	2.25 (1.75-2.86)	2.31 (1.81-2.88)	2.05 (1.61-2.61)	2.09 (1.65-2.65)

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Malawi	1.63 (1.45-1.83)	1.66 (1.47-1.86)	1.71 (1.45-2.00)	1.73 (1.46-2.03)	1.56 (1.32-1.84)	1.58 (1.33-1.86)
Malaysia	3.42 (3.11-3.76)	3.57 (3.25-3.93)	3.57 (3.12-4.07)	3.74 (3.29-4.29)	3.27 (2.86-3.75)	3.40 (2.95-3.87)
Maldives	3.68 (3.00-4.49)	3.31 (2.58-4.17)	3.84 (2.77-5.05)	3.47 (2.37-4.88)	3.50 (2.56-4.65)	3.14 (2.18-4.26)
Mali	3.21 (2.71-3.74)	3.15 (2.67-3.76)	3.38 (2.69-4.28)	3.31 (2.57-4.20)	3.05 (2.38-3.86)	3.01 (2.35-3.80)
Malta	3.88 (3.53-4.25)	4.10 (3.74-4.50)	4.19 (3.66-4.75)	4.31 (3.78-4.89)	3.58 (3.14-4.03)	3.90 (3.44-4.45)
Marshall Islands	2.49 (2.11-2.94)	2.55 (2.15-3.01)	2.60 (2.05-3.31)	2.68 (2.12-3.40)	2.37 (1.87-3.00)	2.43 (1.88-3.05)
Mauritania	3.10 (2.61-3.69)	2.97 (2.49-3.48)	3.25 (2.53-4.15)	3.12 (2.43-3.99)	2.96 (2.32-3.75)	2.84 (2.21-3.57)
Mauritius	5.05 (4.23-5.93)	5.45 (4.57-6.50)	5.28 (4.10-6.65)	5.71 (4.40-7.28)	4.83 (3.77-6.20)	5.20 (4.06-6.60)
Mexico	2.71 (2.54-2.90)	2.76 (2.57-2.94)	2.85 (2.59-3.14)	2.89 (2.62-3.17)	2.58 (2.35-2.85)	2.63 (2.39-2.89)
Micronesia, Federated States of	2.51 (2.11-2.94)	2.56 (2.17-3.03)	2.62 (2.06-3.29)	2.68 (2.12-3.37)	2.39 (1.84-3.00)	2.44 (1.88-3.04)
Moldova, Republic of	3.59 (3.03-4.31)	3.95 (3.32-4.65)	3.80 (3.00-4.81)	4.13 (3.27-5.28)	3.41 (2.72-4.29)	3.79 (2.93-4.79)
Mongolia	5.18 (4.90-5.46)	5.14 (4.84-5.43)	5.43 (5.02-5.86)	5.38 (4.95-5.84)	4.94 (4.60-5.31)	4.91 (4.54-5.33)
Montenegro	3.15 (2.63-3.72)	3.63 (3.08-4.23)	3.31 (2.59-4.16)	3.81 (3.03-4.79)	2.99 (2.33-3.75)	3.45 (2.76-4.30)
Morocco	3.96 (3.34-4.66)	4.31 (3.67-5.06)	4.17 (3.28-5.21)	4.53 (3.55-5.78)	3.77 (2.97-4.65)	4.11 (3.24-5.12)
Mozambique	2.13 (1.79-2.51)	2.24 (1.86-2.65)	2.24 (1.75-2.84)	2.36 (1.85-2.98)	2.04 (1.60-2.57)	2.13 (1.67-2.75)
Myanmar	4.56 (3.81-5.37)	4.49 (3.75-5.29)	4.77 (3.68-5.99)	4.71 (3.63-5.96)	4.36 (3.43-5.56)	4.27 (3.36-5.36)
Namibia	2.59 (2.20-3.05)	2.64 (2.24-3.09)	2.72 (2.10-3.43)	2.78 (2.17-3.43)	2.47 (1.92-3.12)	2.51 (2.00-3.15)
Nepal	3.87 (3.27-4.57)	3.89 (3.30-4.59)	4.06 (3.22-5.09)	4.07 (3.23-5.20)	3.69 (2.89-4.63)	3.73 (2.89-4.61)
Netherlands	3.44 (3.25-3.65)	3.32 (3.10-3.56)	3.72 (3.44-4.02)	3.50 (3.17-3.84)	3.17 (2.93-3.46)	3.15 (2.87-3.45)
New Zealand	3.27 (3.15-3.41)	3.47 (3.33-3.63)	3.44 (3.25-3.64)	3.65 (3.43-3.89)	3.12 (2.94-3.30)	3.31 (3.11-3.51)
Nicaragua	3.15 (2.65-3.78)	3.22 (2.72-3.83)	3.30 (2.56-4.22)	3.37 (2.57-4.26)	3.00 (2.33-3.83)	3.09 (2.41-3.88)
Niger	3.11 (2.60-3.66)	2.92 (2.48-3.44)	3.24 (2.54-4.04)	3.05 (2.37-3.82)	2.98 (2.32-3.74)	2.79 (2.17-3.47)
Nigeria	2.81 (2.50-3.17)	2.82 (2.51-3.17)	2.94 (2.51-3.45)	2.96 (2.52-3.48)	2.69 (2.29-3.18)	2.69 (2.30-3.17)
Norway	3.67 (3.10-4.36)	3.80 (3.24-4.49)	3.96 (3.10-4.96)	4.01 (3.15-5.06)	3.38 (2.63-4.18)	3.58 (2.77-4.51)
Oman	3.37 (2.81-4.01)	3.78 (3.17-4.46)	3.50 (2.70-4.38)	3.93 (3.08-4.93)	3.18 (2.50-4.00)	3.56 (2.82-4.46)
Pakistan	4.03 (3.42-4.73)	3.91 (3.32-4.66)	4.20 (3.31-5.24)	4.05 (3.18-5.14)	3.83 (3.01-4.75)	3.75 (2.97-4.77)
Palestinian Territory, Occupied	3.31 (2.77-3.93)	3.86 (3.24-4.57)	3.47 (2.72-4.48)	4.04 (3.16-5.13)	3.15 (2.45-3.96)	3.69 (2.87-4.65)
Panama	3.35 (2.84-4.00)	3.39 (2.89-3.98)	3.52 (2.82-4.42)	3.54 (2.79-4.55)	3.18 (2.51-3.99)	3.25 (2.54-4.03)
Papua New Guinea	2.45 (2.04-2.91)	2.45 (2.07-2.86)	2.57 (2.01-3.27)	2.58 (2.01-3.22)	2.32 (1.79-2.93)	2.33 (1.83-2.91)
Paraguay	4.01 (3.38-4.76)	4.31 (3.66-5.09)	4.23 (3.32-5.41)	4.52 (3.55-5.69)	3.80 (3.00-4.72)	4.10 (3.21-5.17)
Peru	3.05 (2.57-3.62)	3.07 (2.58-3.60)	3.20 (2.49-4.08)	3.22 (2.53-4.03)	2.91 (2.23-3.70)	2.91 (2.31-3.69)
Philippines	4.22 (3.55-4.99)	4.29 (3.65-5.10)	4.39 (3.44-5.50)	4.49 (3.50-5.68)	4.05 (3.19-5.09)	4.10 (3.20-5.29)
Poland	3.82 (3.57-4.07)	3.84 (3.61-4.06)	4.02 (3.67-4.40)	4.03 (3.68-4.38)	3.63 (3.29-3.98)	3.66 (3.37-4.00)
Portugal	3.88 (3.64-4.13)	4.24 (3.98-4.51)	4.20 (3.83-4.60)	4.46 (4.07-4.89)	3.58 (3.26-3.93)	4.03 (3.68-4.41)
Qatar	3.53 (2.87-4.28)	4.21 (3.34-5.17)	3.61 (2.78-4.55)	4.29 (3.25-5.44)	3.30 (2.59-4.27)	3.90 (2.98-5.04)
Romania	3.77 (3.21-4.43)	4.12 (3.46-4.83)	3.97 (3.11-4.99)	4.32 (3.42-5.43)	3.58 (2.85-4.41)	3.92 (3.08-4.93)

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Russian Federation	3.72 (3.53-3.93)	4.17 (3.95-4.40)	3.91 (3.64-4.24)	4.38 (4.07-4.72)	3.56 (3.29-3.84)	3.99 (3.69-4.29)
Rwanda	1.52 (1.23-1.88)	1.60 (1.31-1.95)	1.59 (1.18-2.11)	1.67 (1.25-2.14)	1.45 (1.07-1.91)	1.53 (1.12-2.03)
Saint Lucia	2.84 (2.54-3.15)	2.93 (2.58-3.30)	2.98 (2.56-3.43)	3.08 (2.60-3.60)	2.72 (2.32-3.16)	2.80 (2.34-3.31)
Saint Vincent and the Grenadines	2.70 (2.29-3.18)	2.82 (2.39-3.32)	2.83 (2.26-3.50)	2.94 (2.30-3.69)	2.58 (2.03-3.24)	2.70 (2.09-3.46)
Samoa	2.15 (1.97-2.36)	2.07 (1.82-2.34)	2.25 (1.99-2.56)	2.16 (1.82-2.57)	2.05 (1.80-2.31)	1.97 (1.66-2.32)
Sao Tome and Principe	2.37 (1.98-2.84)	2.36 (1.97-2.77)	2.48 (1.93-3.19)	2.47 (1.93-3.14)	2.26 (1.74-2.93)	2.25 (1.77-2.87)
Saudi Arabia	2.98 (2.47-3.54)	3.20 (2.63-3.78)	3.08 (2.41-3.92)	3.33 (2.54-4.15)	2.82 (2.17-3.65)	3.03 (2.36-3.90)
Senegal	2.98 (2.49-3.52)	3.15 (2.67-3.71)	3.11 (2.41-3.91)	3.32 (2.55-4.17)	2.85 (2.23-3.59)	2.99 (2.34-3.77)
Serbia	3.21 (2.69-3.79)	3.67 (3.05-4.39)	3.37 (2.67-4.18)	3.87 (2.94-4.95)	3.05 (2.35-3.88)	3.48 (2.68-4.40)
Seychelles	4.36 (3.63-5.20)	4.34 (3.62-5.12)	4.59 (3.54-5.84)	4.57 (3.55-5.74)	4.14 (3.18-5.21)	4.12 (3.21-5.17)
Sierra Leone	2.52 (2.10-2.99)	2.51 (2.11-2.94)	2.64 (2.09-3.34)	2.63 (2.05-3.25)	2.40 (1.88-3.03)	2.39 (1.89-2.96)
Singapore	5.03 (4.28-5.90)	5.14 (4.36-6.02)	5.25 (4.13-6.49)	5.37 (4.22-6.79)	4.81 (3.70-6.07)	4.92 (3.89-6.18)
Slovakia	3.64 (3.07-4.29)	4.23 (3.55-5.00)	3.82 (3.01-4.78)	4.46 (3.51-5.58)	3.48 (2.73-4.36)	4.02 (3.13-4.97)
Slovenia	3.87 (3.52-4.23)	4.23 (3.83-4.67)	4.07 (3.56-4.61)	4.43 (3.86-5.07)	3.68 (3.21-4.22)	4.02 (3.50-4.61)
Solomon Islands	2.26 (1.91-2.65)	2.33 (1.96-2.76)	2.37 (1.85-2.98)	2.44 (1.93-3.11)	2.14 (1.66-2.68)	2.22 (1.74-2.77)
Somalia	2.04 (1.71-2.42)	2.07 (1.77-2.43)	2.14 (1.67-2.69)	2.17 (1.74-2.71)	1.95 (1.53-2.45)	1.97 (1.53-2.51)
South Africa	2.41 (2.28-2.55)	2.48 (2.34-2.62)	2.53 (2.33-2.74)	2.61 (2.41-2.82)	2.30 (2.12-2.50)	2.37 (2.17-2.56)
Spain	3.72 (3.49-3.99)	4.02 (3.77-4.27)	4.01 (3.66-4.41)	4.24 (3.89-4.61)	3.44 (3.15-3.75)	3.81 (3.50-4.15)
Sri Lanka	3.92 (3.33-4.60)	3.87 (3.27-4.54)	4.10 (3.23-5.10)	4.07 (3.16-5.11)	3.75 (2.97-4.66)	3.69 (2.87-4.67)
Sudan	2.31 (1.96-2.71)	2.37 (2.01-2.79)	2.43 (1.92-3.02)	2.49 (1.93-3.17)	2.21 (1.74-2.79)	2.26 (1.77-2.82)
Suriname	2.66 (2.25-3.12)	2.89 (2.43-3.42)	2.79 (2.19-3.48)	3.03 (2.35-3.85)	2.53 (1.99-3.15)	2.76 (2.16-3.51)
Swaziland	2.63 (2.20-3.09)	2.53 (2.16-3.02)	2.77 (2.16-3.48)	2.67 (2.11-3.40)	2.52 (1.99-3.17)	2.42 (1.90-2.99)
Sweden	3.50 (3.32-3.70)	3.65 (3.46-3.85)	3.77 (3.50-4.05)	3.84 (3.56-4.15)	3.23 (3.01-3.47)	3.46 (3.22-3.71)
Switzerland	3.64 (3.41-3.89)	3.61 (3.40-3.85)	3.93 (3.60-4.29)	3.80 (3.48-4.13)	3.36 (3.08-3.67)	3.42 (3.13-3.74)
Syrian Arab Republic	3.80 (3.22-4.46)	4.18 (3.53-4.92)	3.97 (3.13-4.98)	4.37 (3.43-5.49)	3.64 (2.86-4.53)	3.99 (3.10-4.98)
Taiwan, Province of China	3.40 (3.12-3.69)	3.92 (3.66-4.17)	3.55 (3.14-3.99)	4.10 (3.72-4.48)	3.23 (2.85-3.61)	3.74 (3.40-4.11)
Tajikistan	5.03 (4.23-5.97)	5.40 (4.64-6.27)	5.29 (4.12-6.55)	5.70 (4.47-7.26)	4.79 (3.76-5.97)	5.13 (4.01-6.36)
Tanzania, United Republic of	2.81 (2.53-3.14)	2.75 (2.45-3.08)	2.94 (2.52-3.43)	2.88 (2.46-3.42)	2.69 (2.28-3.16)	2.62 (2.20-3.08)
Thailand	5.23 (4.82-5.66)	5.31 (4.88-5.75)	5.49 (4.94-6.15)	5.58 (4.97-6.18)	4.99 (4.46-5.58)	5.06 (4.54-5.65)
Timor-Leste	4.59 (3.83-5.38)	4.47 (3.71-5.32)	4.80 (3.78-5.98)	4.69 (3.61-5.91)	4.38 (3.45-5.56)	4.25 (3.39-5.37)
Togo	2.81 (2.40-3.33)	2.78 (2.36-3.34)	2.96 (2.29-3.82)	2.94 (2.30-3.77)	2.67 (2.12-3.35)	2.64 (2.09-3.29)
Tonga	2.61 (2.17-3.10)	2.73 (2.28-3.18)	2.72 (2.10-3.47)	2.88 (2.21-3.61)	2.50 (1.94-3.18)	2.58 (2.00-3.32)
Trinidad and Tobago	2.75 (2.51-3.01)	2.93 (2.63-3.23)	2.90 (2.55-3.28)	3.07 (2.64-3.56)	2.62 (2.30-2.95)	2.80 (2.43-3.19)
Tunisia	4.12 (3.51-4.91)	4.43 (3.72-5.23)	4.31 (3.37-5.44)	4.63 (3.61-5.83)	3.93 (3.09-4.91)	4.24 (3.32-5.34)
Turkey	3.76 (3.50-4.06)	4.10 (3.80-4.43)	3.94 (3.51-4.39)	4.30 (3.85-4.78)	3.59 (3.22-3.97)	3.91 (3.50-4.37)
Turkmenistan	5.10 (4.35-6.06)	5.43 (4.64-6.35)	5.35 (4.27-6.69)	5.69 (4.48-7.14)	4.87 (3.92-6.12)	5.20 (4.12-6.38)

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Uganda	1.95 (1.58-2.37)	2.11 (1.75-2.52)	2.05 (1.55-2.68)	2.21 (1.72-2.82)	1.86 (1.39-2.43)	2.00 (1.54-2.54)
Ukraine	3.85 (3.25-4.53)	4.19 (3.56-4.93)	4.05 (3.18-5.00)	4.41 (3.45-5.46)	3.68 (2.88-4.69)	4.01 (3.13-5.05)
United Arab Emirates	3.40 (2.73-4.16)	3.67 (2.97-4.47)	3.50 (2.64-4.48)	3.76 (2.92-4.78)	3.16 (2.38-4.12)	3.43 (2.65-4.39)
United Kingdom	3.48 (3.32-3.64)	3.61 (3.45-3.78)	3.75 (3.53-4.02)	3.80 (3.57-4.05)	3.21 (3.02-3.42)	3.42 (3.22-3.63)
United States	3.44 (3.35-3.53)	3.60 (3.50-3.70)	3.62 (3.48-3.77)	3.78 (3.63-3.93)	3.26 (3.14-3.40)	3.43 (3.29-3.56)
Uruguay	2.77 (2.34-3.27)	2.73 (2.32-3.18)	2.90 (2.24-3.65)	2.87 (2.27-3.58)	2.65 (2.09-3.35)	2.60 (2.05-3.28)
Uzbekistan	5.34 (4.50-6.25)	5.63 (4.83-6.53)	5.62 (4.47-6.93)	5.91 (4.67-7.41)	5.08 (4.04-6.39)	5.36 (4.28-6.66)
Vanuatu	2.17 (1.83-2.56)	2.24 (1.90-2.65)	2.26 (1.75-2.88)	2.33 (1.80-2.95)	2.07 (1.63-2.61)	2.14 (1.64-2.70)
Venezuela, Bolivarian Republic of	3.37 (2.84-3.92)	3.55 (3.01-4.18)	3.52 (2.81-4.39)	3.72 (2.92-4.66)	3.22 (2.52-3.98)	3.39 (2.65-4.21)
Viet Nam	4.48 (3.82-5.27)	4.59 (3.81-5.46)	4.67 (3.70-5.88)	4.83 (3.69-6.16)	4.31 (3.35-5.39)	4.37 (3.43-5.47)
Yemen	3.27 (2.76-3.86)	3.37 (2.82-4.05)	3.43 (2.65-4.38)	3.55 (2.74-4.53)	3.13 (2.46-3.94)	3.21 (2.48-4.13)
Zambia	2.27 (1.91-2.69)	2.27 (1.91-2.70)	2.39 (1.84-3.03)	2.38 (1.91-3.00)	2.15 (1.67-2.70)	2.17 (1.70-2.71)
Zimbabwe	3.06 (2.82-3.29)	3.10 (2.81-3.39)	3.21 (2.85-3.59)	3.25 (2.83-3.66)	2.92 (2.59-3.23)	2.95 (2.58-3.39)

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Global, regional, and national sodium intakes in 1990 and 2010: a systematic analysis of 24-hour urinary sodium excretion and dietary surveys worldwide

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ABSTRACT (300 words)

Objectives

To estimate global, regional (21 regions) and national (187 countries) sodium intakes in adults in 1990 and 2010.

Design

Bayesian hierarchical modeling using all identifiable primary sources.

Data sources and eligibility

We searched and obtained published and unpublished data from 142 surveys of 24-hour urinary sodium and 103 of dietary sodium conducted between 1980 and 2010 across 66 countries. Dietary estimates were converted to urine equivalents based on 79 pairs of dual measurements.

Modeling methods

Bayesian hierarchical modeling used survey data and their characteristics ~~incorporated representativeness of survey samples, extent of missing data and comparability of measurements~~ to estimate mean sodium intake, by sex, 5y age group, ~~and year,~~ and associated uncertainty for persons aged 20+ in 187 countries in 1990 and 2010. Country-level covariates were national income per person and ~~indices of~~ composition of food supplies~~types of food available~~.

Main outcome measures

Mean sodium intake (g/d) as estimable by 24h urine collections, without adjustment for non-urinary losses.

Results

In 2010, global mean sodium intake was 3·95 g/d (95% uncertainty interval: 3·89-4·01). This was nearly twice the WHO recommended limit of 2 g/d and~~,~~ equivalent to 10·06 (9·88-10·21) g/d of salt. Intake in men was ~10% higher than in women; differences by age were small. Intakes were highest in East Asia, Central Asia, and Eastern Europe (mean >4·2 g/d), and in Central Europe and Middle East/North Africa (3·9 to 4·2 g/d). Regional mean intakes in North America, Western Europe, and Australia/New Zealand ranged from 3·4 to 3·8 g/d. Intakes were lower (<3·3 g/d), but

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more uncertain, in Sub-Saharan Africa and Latin America. Between 1990 and 2010, modest, but ~~somewhat~~ uncertain, increases in sodium intakes were identified.

Conclusion

Sodium intakes ~~greatly~~ exceed recommended levels in almost all countries ~~worldwide~~ with small differences by age and sex. Virtually all populations would benefit from sodium reduction, supported by enhanced surveillance.

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Article Summary

Article Focus

1. Because excess sodium intakes raise blood pressure, the leading global risk factor for cardiovascular diseases, knowledge of intake levels provides an important foundation for measures to reduce non-communicable diseases globally.
2. We used Bayesian hierarchical modeling with data from 245 surveys to estimate sodium intakes in adults in 187 countries.

Key messages

1. Mean intake of sodium, globally, was ~4g/d, equivalent to ~10 g/d of salt and about twice the WHO recommended limit of 2 g/d.~~with modest v~~ Variation by age and sex was modest.
2. Intakes varied 2½ fold across 21 global regions, being highest in East and Central Asia and Eastern Europe and lowest in sub-Saharan Africa and Latin America.
3. Virtually all countries would benefit from reduced sodium intakes, supported by enhanced surveillance.

Strengths and limitations of the study

Strengths

1. This is the first study to produce comprehensive and comparable estimates of sodium intake, and their uncertainties, globally.
2. We identified and made use of a much larger set of primary data sources than previous collations.
3. Our Bayesian estimation model used all available data by converting self-reported dietary values to comparable 24 hr urine values and was informed by regional hierarchies and country-level covariates.

Weaknesses

1. In the absence of ~~an~~ established conventions for measuring and reporting sodium intakes we have used 24hr urinary excretion, uncorrected for non-renal losses, as a proxy measure. Variation in non-renal (sweat) losses associated with climate or activity levels could introduce additional biases.

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2. Use of biochemical markers to assess and control completeness of urine collections was uncommon impeding adjustment for likely downward biases from incomplete collections.
3. 24h urine collections mostly came from small surveys that were not based on national probability sampling with consequent sampling bias.
4. Primary data was deficient for much of the global population.

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Introduction

Excess sodium intake raises blood pressure (BP),[1 2] a major risk factor for cardiovascular disease,[3 4] and increases risk of stomach~~gastric~~ cancer,[5 6] a leading fatal cancer globally.[7] Based on established risks across the current range of population intake levels, major international and national agencies have prioritized sodium reduction to decrease the burdens of non-communicable disease.[8–11] Such efforts have been limited, at least in part, by absence of reliable and comparable data on sodium intake for most countries.[12] This has made it difficult to quantify global, regional, or national levels of dietary sodium and the corresponding preventable disease burdens. Changes in national, regional, and global sodium intakes over time are also not well established.

We therefore systematically reviewed and accessed published and unpublished country-specific surveys of sodium intakes from around the world as part of the 2010 Global Burden of Diseases, Injuries, and Risk Factors (GBD) Study. We developed quantitative methods to produce comparable global, regional, and country-specific estimates of sodium intake, by age and sex subgroups, in 1990 and 2010.

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Methods

Study design

We estimated mean sodium intake and its uncertainty by age and sex for 187 countries in 1990 and 2010. Our strategy included 3 steps: (1) systematic searches for data sources from around the world on individual-level sodium intake, including by age and sex subgroups; (2) retrieval of data, including assessment of data quality, representativeness, missingness, and uncertainty, and quantification of measurement comparability across different survey methods; and (3) application of an hierarchical Bayesian ~~imputation~~ estimation model to incorporate missingness, comparability, and sampling and modeling uncertainty to estimate sodium intake by age, sex, country, and time worldwide.

Identification of surveys, access, and extraction

Between Oct 2008 and Nov 2011, we performed systematic searches to identify both urine-based and diet-based surveys (**Figure 1**). The overall search strategy and results have been described.[13 14] Sources for diet-based measurements were primarily national surveys that had incorporated sampling weights, as appropriate. For countries with no national dietary surveys identified, other potential sources were considered, including subnational surveys, household budget survey data, baseline measurements in large cohort studies, the WHO InfoBase, and the STEPS database, published government reports, published sources not previously identified and unpublished data. These searches were complemented by extensive direct contacts with local experts and requests for detailed data.

For urine-based assessments, we searched MEDLINE using the following terms:
((World regions (Mesh)) OR (Name of countries)) AND (salt OR sodium OR Na) AND (intake OR ingest* OR eat* OR consum* OR diet* OR urin* OR excret*)
Limits:Humans, All Adult: 19+ years, Publication Date from 1980/1/1

We also searched for national dietary survey reports and ~~–~~ manually searched the reference lists of retrieved articles. We searched publications and web pages of organizations engaged in sodium reduction at national (e.g. UK Food Standards Agency), regional (e.g. European salt reduction program), and international levels (e.g. World Action on Salt and Health) and contacted the nutritional departments of WHO regional offices. Where duplicate sources were

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identified we retained the report with most detail and with most information on the primary metric.

Surveys could be included if they were performed after 1980 and were from a sample that was representative of a national (or if no national survey, a subnational) population; if assessment methods included 24-hour urinary excretion measurements, a diet assessment tool (e.g., diet record, diet recall, food frequency questionnaire [FFQ]), or both; and if there was no evidence suggestive of major selection bias. For example, we excluded studies based exclusively on individuals with hypertension or on pregnant women. Surveys conducted at different locations within a country were counted as different surveys unless they were part of a formal multi-stage sampling design intended to characterize a larger (regional or national) population.

In sum, we identified 142 urine-based surveys and 103 diet-based surveys – with 26 of each forming paired surveys of the same population (**Figure 1 and Table 1**).

Data retrieval and standardization

Because published exposure data were often limited or not in the required format, we obtained data by direct contacts with government officials, scientists, and survey report authors from across the world, who joined our group as Corresponding Members (see list of contributors and **Supplementary Table**). These individuals provided us with either raw data or standardized analyses using an electronic form.[13] Survey characteristics were extracted including date of fieldwork, sampling methods, proportion participating, representativeness, population characteristics, number of subjects by age and sex strata, types and number of measurements (urine, diet including type of dietary tool), validation methods, energy adjustment (for diet-based data), and mean and SD of sodium intake by age and sex groups. To reduce measurement error in dietary estimates by accounting for tendencies to under- or over-report intakes of all foods,[15] dietary data were energy-standardized to 2,000 kilocalories/d (8.37MJ/d). Urinary data were not standardized to energy.

Due to known larger measurement errors in diet-based methods,[16–18] we chose 24-h urinary excretion as our primary metric, and dietary estimates as our secondary metric. We estimated the quantitative relationship between urine and dietary measurements using 79 datapoints from 26 surveys having data on the same individuals in both metrics, and used these results to estimate urinary excretions corresponding to the dietary values in the remaining dietary

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surveys (**Figure 2**). Consequently, our final estimates represent sodium 'intake' using 24-hour urine collections as the reference. We elected not to adjust these final estimates for non-urinary losses (e.g., sweat) because urinary excretion accounts, on average, for ~90% of dietary intake[19–21] and also to enhance comparability with prior estimates of sodium intake (mostly reported as unadjusted 24-h urinary sodium excretion). The possibility that sweat losses vary systematically with climate needs to be clarified by further research. We also did not attempt to adjust these estimates for potential incomplete collections, which are common even in research settings.[22] Thus, our final estimates of dietary intake can be considered conservative estimates of true sodium consumption.

Bayesian hierarchical ~~imputation~~model

To account for differences in missingness, representativeness, and measurement methods and to incorporate and quantify uncertainty, we specifi~~develop~~ed a Bayesian hierarchical ~~imputation~~ model (using the DisMod-MR model developed ~~within~~as part the Global Burden of Disease Project) to estimate mean sodium intake across the world by sex, age, ~~time, and~~ and country for 2 calendar years – 1990 and 2010. Data from country-specific age and sex subgroups were used simultaneously as inputs, with country, regional, and global random effects. This structure allowed the model to borrow information across countries and regions as necessary, using spatial-temporal regression and Gaussian process regression, while accounting for and quantifying the resulting statistical uncertainties. Representativeness (national with or without probability sampling, subnational) was included as a survey-level covariate. Time-varying country-level covariates further informed the estimates, including lag-distributed national per capita income (inflation and purchasing power parity adjusted[23]) and national dietary patterns characterized by scores on 4 ~~factor~~components ~~variables~~ from a dimension reduction through principal components~~n~~ analysis of 15 diet composition variables from~~of~~ the Food and Agriculture Organization ~~FAO~~ food balance sheets. Because sodium intakes may be non-linearly associated with age, relationships with ~~data on~~ age were modeled ~~incorporated~~ using a cubic spline ~~model~~.

We fitted the Bayesian model with the Markov chain Monte Carlo (MCMC) algorithm and ran 1000 iterations. Posterior distributions of mean sodium intake for each country by age and sex subgroups were obtained, incorporating and reflecting the above sources of uncertainty. Ninety-five percent uncertainty intervals were obtained from the 2.5th and 97.5th percentiles of the posterior distributions.

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Intakes were estimated from the model for 5-year age intervals, by sex for adults aged 20 years or more for each country for 1990 and 2010.~~, sex, and time period, for adults aged 20 years or more~~. Regional estimates were calculated as population-weighted averages of the constituent country estimates. Intakes for each country, region and time period are reported, both actual intakes (potentially of greater relevance to assessing contributions to local disease burdens) and age standardized intakes[24] (for comparing levels across populations and over time).

Further details on the modeling process and its outputs are provided in the **Methods supplement**.

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Results

Data sources

We identified and obtained data from 245 surveys, including 142 reporting 24-hr urinary sodium data and 103 reporting dietary sodium data, with 26 of each forming urine/diet survey pairs. These surveys were conducted in 66 countries comprising 74% of the global adult population. Sixty one percent (149) of the surveys were conducted in high-income regions and 40% (96) in low- and mid-income regions (**Table** 1 with details for each contributing survey provided in the **Supplementary Table**). East Asia (23 surveys) was the only low- or mid- income region with more than 10 surveys. Counting as a datapoint each estimate for an age-sex stratum~~In sum~~, the identified surveys provided 1,346 ~~age and sex specific~~ datapoints (mean: 5.5 per survey), of which 651 were urine-based and 695 were diet-based. More than half (376/651) of the urine-based datapoints came from the Intersalt Study, a major international study with standardized protocols conducted between 1985 and 1987.[25] Fifty datapoints, all in European regions, were from collections biochemically validated for completeness using para-amino benzoic acid (PABA).[26] Ten countries had at least 20 urine-based datapoints, including the USA (86), UK (86), Japan (48), China (41), Italy (33), Belgium (24), Finland (24), Germany (24), New Zealand (22) and Netherlands (20). Urine-based data was relatively scarce in the highest age groups, with only 2 urine-based datapoints for age groups 70+ y; in contrast, 97 diet-based datapoints were available at these older ages.

Global and regional sodium intakes

In 2010 global, mean (95% uncertainty interval) sodium intake in adults was 3.95 (3.89-4.01) g/d, equivalent to salt intakes of 10.06 (9.88-10.21) g/d (based on the assumption, conventional in this context, that all the sodium comes from salt). Globally, mean intake in men was, as expected, ~~about 10%~~ higher than that in women: 4.14 (4.04-4.23) versus 3.77 (3.69 – 3.85) g/d, respectively. In every region, sodium intake was lower in women, ranging from 8.9% lower in South Asia to 10.7% lower in Western Europe. Given these consistent, modest differences, additional findings are presented for both sexes combined.

Interestingly, we also identified relatively little variation in sodium intakes by age. Globally, mean intakes rose by ~6% from age 25-29 (3.78 g/d) to age 40-44 (4.04 g/d), and then remained relatively constant thereafter. This pattern was broadly consistent across each of the 21 GBD Study regions (**Figure 3)**.

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In contrast to small within-region differences by age or sex, marked differences in intake were identified across regions (**Figures 4 and 5**). Asian regions had highest intakes – East Asia (mean, 95% uncertainty interval~~UI~~) 4.80 (4.59-5.02) g/d, Asia Pacific High Income (mainly Japan and South Korea) 5.00 (4.85-5.16) g/d, and Central Asia 5.51 (5.11-5.95) g/d – corresponding to daily salt intakes of 12.21, 12.71 and 14.01 g, respectively. Very high intakes were also seen in Eastern Europe (4.18 (3.95-4.41) g/d, Central Europe (3.92 (3.73-4.12) g/d, and the Middle East and North Africa (3.92 (3.74-4.12) g/d. Among high-income Western regions, sodium consumption was 3.44 (3.32-3.55) g/d in Australia/New Zealand, 3.62 (3.52-3.72) g/d in the USA/Canada, and 3.81 (3.72-3.91) g/d in Western Europe - equivalent to salt intakes of 8.75, 9.21 and 9.69 g/d, respectively.

Sub-Saharan Africa, Latin America, and the Caribbean and Oceania tended to have lower estimated intakes, but also were based on fewest data sources among all the regions, with resulting larger uncertainties. For example, estimated intakes in Sub-Saharan Africa ranged from 2.18 (2.05-2.32) g/d in Eastern Sub-Saharan Africa to 2.76 (2.58-2.95) g/d in Western Sub-Saharan Africa; and estimated intake in Oceania was 2.48 (2.18–2.80) g/d. Mean intakes were similar or higher in Latin America and the Caribbean, including 2.61 (2.40– 2.83) g/d in the Caribbean, and 3.19 (3.03-3.34) g/d in Central Latin America. Intake in Tropical Latin America (mainly Brazil) was higher than in other Latin American regions and, at 4.11 (4.01–4.22) g/d, exceeded that for US/Canada.

National sodium intakes

We identified substantial variation in estimated sodium intakes across nations (**Figure 6(a), Table 2**). The statistical uncertainty around the estimated intakes for individual countries (**Figure 6(b)**) was larger than that for world regions, especially for countries with no primary data. Thus, relative rankings across different nations should be interpreted in the light of their relative uncertainty levels.

In Western Europe, a region with relatively low uncertainty, estimated mean intakes ranged from 3.28 (2.99-3.59) g/d (Denmark) to 4.43 (4.23-4.62) g/d (Italy). Estimated intakes in the Netherlands, Belgium, Germany and Iceland ranged from 3.33 to 3.59 g/d; in another 12 Western European countries, from 3.62 (3.41-3.86) g/d (Switzerland) to 4.03 (3.78-4.27) g/d (Spain) g/d; and in Cyprus, Luxemburg, Malta, Portugal and Italy, from 4.06 to 4.43 g/d.

Estimated intakes within North Africa/Middle East were also diverse, ranging from 3.13 (2.77–5.54) g/d in Lebanon to 5.37 (4.85-5.92) g/d in Bahrain. In E~~e~~astern Sub-Saharan

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Africa, estimated consumption was higher in Mauritius (5.45 [4.57-6.50] g/d) than in other neighboring countries (mean intakes ranging from 1.47 to 4.32 g/d).

In other regions, less variation in sodium intake was identified. For example, sodium consumption was very similar in the USA (3.61 (3.51-3.71) g/d) vs. Canada (3.72 (3.59 – 3.84) g/d). Additionally, relatively small within-region differences were observed in Australia/New Zealand, Eastern Europe, South Asia, and each of the regions of Latin America.

Overall in 2010, estimated mean intakes in 181 of 187 countries, whose total adult population accounted for ~~representing~~ 99.2% of the world ~~'s~~ adult population, exceeded the WHO recommendation of 2.00 g/d sodium (~5 g/d salt).[27] In 119 countries (with 88.3% of the world's adult population), estimated mean intakes exceeded~~ing~~ this recommended amount by at least 1 g/d; and in 51 countries (44.8% of the world's adult population), estimated mean intakes were more than double this recommended amount.

Changes over time

Globally between 1990 and 2010, modest, statistically non-significant global increases were seen, from 4.02 (3.93-4.11) to 4.14 (4.04-4.23) g/d in males and from 3.63 (3.55–3.71) to 3.77 (3.69–3.85) g/d in females. By region, estimated increases were larger for East Asia, from 4.37 (4.18-4.58) to 4.80 (4.59-5.02) g/d; and Eastern Europe, from 3.76 (3.55-3.97) to 4.18 (3.95-4.41) g/d (for both sexes combined). These estimated increases appeared sensitive to the large proportion of urine-based data in earlier years that was collected in Intersalt (1985-87). When only diet-based data were evaluated, the direction of secular change tended to reverse (data not shown). Thus, estimates of trends over time should be interpreted cautiously. Figure 5 and Table 2 show changes in age-standardised estimates for regions and countries respectively.

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Discussion

Our findings provide systematically assessed and comprehensive evidence on global, regional, and national intake levels and patterns of sodium consumption, including by age and sex. Several findings are notable. Within regions and countries, only small differences were evident comparing younger to older adults or men to women. This suggests relatively constant and common exposures to sodium within populations. On the other hand, marked differences were evident between regions and between countries. Interestingly, these differences were not strongly related to national income, suggesting that in contrast to many other dietary components that are linked to national wealth or affluence, sodium intake is more strongly influenced by other factors. For example, the geographic distribution of highest intakes from East Asia to Eastern and Central Europe suggests a "Silk Road" pattern, implying shared retentions from past transportation and food cultures such as use of salt for food preservation.[28]

A recent Institute of Medicine committee concluded that, based only on studies of the association between sodium intake and incidence of clinical events (i.e. ignoring effects on blood pressure), evidence was insufficient to conclusively choose between modest (e.g., 2.3 g/d) vs. low (e.g., 1.5 g/d) sodium intakes as long term targets for populations.[29] The resulting controversy over this somewhat~~relatively~~ narrowly-based judg~~state~~ment overshadowed their other main conclusion that, considered collectively, the evidence indicated a positive relationship between high sodium intakes and cardiovascular events and was consistent with BP-raising effects of dietary sodium. Numerous other organizations have systematically reviewed the evidence and concluded that ~~high~~ intakes of sodium above levels variously specified in the range 1.2 to 2.4 g/d increase cardiovascular risk.[11 27 30] Thus, whereas identified optimal target intakes have varied from 1.20 to 2.4 g/d,[27 30 31] all have consistently concluded that sodium intakes above these levels are adverse for health. Our findings demonstrate that, whether ~~for~~ modest (2 to 2.4 g/d) or low (1.20 to 1.5 g/d) target intakes are designated as optimal, virtually every nation in the world, and each age and sex group within these nations, exceed these~~s~~ optimal intakes.

T~~Reporting first in 1988, t~~he Intersalt study provided the first extensive body of comparable urine based data on sodium consumption globally, with results from 52

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surveys in 30 countries reported in 1988 and 1989.[32] In 2009, Brown and colleagues produced a tabular update of 11 diet-based and 26 urine-based surveys published after Intersalt.[12] We are not aware of any otherprevious reports that have estimaimputed national sodium intake levels globally.

Strengths and innovations of our investigation can also be highlighted. We systematically identified and extracted data from around the world on both urinary and dietary sodium, including many sources of previously unavailable data. We evaluated and incorporated the evidence for systematic differences between urinary and dietary estimates, increasing comparability and allowing us to draw on the different strengths of each. In contrast with diet based surveys many of which were based on national probability samples, urine-based surveys were often of smaller size and representative only of local populations. . Our model takes advantage of all available raw data in the world; a cross-walk to render self-reported dietary values more comparable to 24-hr urine values, based on empirical relations between these measures; and then the relation between these data and global country-level covariates (GDP, age, sex, FAO factor analysis) in a Bayesian hierarchical fashion. ~~Our analytic methods took advantage of all available data but gave precedence to urinary over dietary estimates and to nationally representative over subnational studies, increasing both coverage and validity.~~

Potential limitations should be considered. Primary data sources were limited or missing in many countries. Our model dealt with this by 'borrowing' information within and across countries, regions, and time, based on both country-level and survey-level covariates; it also incorporated both missingness and types of available data to quantify the final uncertainty. ~~In contrast with diet based surveys many of which were based on national probability samples, urine based surveys were often of smaller size and representative only of local populations.~~ For regions and their constituent countries where primary exposure data is limited or absent (e.g. Sub-Saharan Africa, central and Latin America, Andean), relative uncertainty is correspondingly greater: their Monte Carlo standard errors exceed 9% their means, compared to 2.5% for the relatively data rich region of Western Europe. For data deficient regions final estimates correspond to their priors, which depend in turn on spatio-temporal 'borrowing' and on the use of covariates. Model outputs for such regions (Figures S1, S3, S4) show that the coefficients for the fixed effects of the

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FAO diet composition components (especially component 1) are larger than the coefficients on income (which were expected to be low). The assumption of our Bayesian approach is that the final ~~imputed~~estimations ~~data~~, informed by both the raw data, covariates, and regional hierarchy, are closer to the 'truth' than any isolated datapoint. Substantial reduction of the uncertainty in the estimates for data deficient regions and countries must await the carrying out of good quality national surveillance studies so that the dependence of final estimates on priors, and their associated uncertainties, is reduced.

We had more limited data across time to quantify temporal trends in intakes. In addition, our analysis evaluated intakes in 1990 and 2010, which does not exclude larger changes over a broader time horizon. For instance, reported intakes in Japan[33] Portugal[34] and Finland[35] from several decades ago were much higher than our recent estimates. This implies potentially large reductions in sodium intakes in these countries over time frames longer than covered in our study, consistent with changes in traditional methods of food preservation made possible by widespread refrigeration.[36] Conversely, more recent increased global consumption of highly processed foods [37] may be countering or even reversing these historical associations between modernization and declining sodium intakes.

In May 2013, the 66th World Health Assembly followed up the 2011 United Nations High-Level Summit on the Prevention and Control of Non-Communicable Diseases with a resolution endorsing a global action plan that included a proposed 30% reduction in salt/sodium intake.[38] Our findings can help inform the planning and design of such high priority programs. Optimal strategies for reducing sodium will partly depend on the proportion of dietary sodium derived from cooking or table salt (e.g., relatively high in Asian nations) vs. from ~~pre~~prepared or industrialized foods (e.g., the majority in high-income Western nations).[12] In a limited number of high-income countries, sustained, coordinated public health programs have helped lower sodium intakes, for example in Japan,[39] Finland[35] and the UK[40]. The most recent surveillance data from the UK (too late for inclusion in our model) documents a 15% reduction in mean sodium intakes over the preceding decade, coinciding with a coordinated national program which includes formal food industry commitments.[41] Media and educational programs can also have an impact in countries where substantial proportions of dietary sodium are added during household food

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preparation and at the table.[42] Simulations suggest that population-wide sodium reduction strategies would be not only cost-effective, but could be cost-saving.[43–45] While the food industry often cites taste as a major barrier to sodium reduction, our findings provide empiric evidence on the remarkable adaptability of the human palate to preference for salt,[46] with usual sodium intakes varying more than 2.5-fold across world regions and 4-fold across nations.

Our results also highlight data gaps and the need for improved surveillance of sodium intakes using transparent, validated and comparable methods. If a gold standard were specified for the national surveillance of sodium intakes it would likely entail the combination of repeated national probability sampling and the use of 24 hour urine collections biochemically validated for completeness.[22 41] To our knowledge, only the UK has implemented such a system~~only the UK, has an optimal surveillance system, i.e. one that includes serial surveys of national probability samples using urine collections that are biochemically validated for completeness~~.[22 41] Yet, despite the limitations of the primary data sources available to us~~Yet~~, our estimates of mean intakes, interpreted in conjunction with their uncertainties ~~findings on mean levels across and within countries~~ indicate that, for virtually all countries, it is likely to be some time before mean intakes approach levels at which the benefits of further reduction may be uncertain.[29] Thus, the remaining uncertainties highlighted by our work inform the need both for enhanced surveillance and for further research but do not alter the imperative for strong, active public health policies to reduce national sodium intakes from their current levels.

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Contributorship statement

Summary version

ME, JP and DM conceived and designed the study. DM obtained funding. SF, RM, SK and PS designed and carried out the data collection, extraction and coding. SSL and REE designed and carried out the statistical modelling with help from all ~~coauthors~~co-authors. JP and DM drafted the paper which was critically reviewed by all other ~~coauthors~~co-authors. JP and DM had full access to all the data, take full responsibility for its integrity and are guarantors for the paper.

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John Powles: Study concept and design; data collection; data analysis; interpretation of data; drafting of the manuscript; critical revision of the manuscript for important intellectual content.

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FIGURE LEGENDS

Figure 1. Search strategies for global sodium exposure data: urine-based (left) and diet-based (right)

[Footnote] The black dashed lines show dietary Na assessment studies that were identified through the search for 24-hour urinary sodium excretion studies.

Figure 2. Relationship between measured urinary sodium and measured dietary sodium in 79 age/sex strata from 26 survey pairs

[Footnote] The solid line represents the cross-walk regression line (linear regression of log-transformed urinary sodium~~dietary versus~~ on log-transformed diet~~urin~~ary sodium); and the dotted lines, the 95% uncertainty intervals. With the partial exception of 8 age and sex strata (all from 2 of the 3 InterMap study sites in China) in which urinary sodium levels were systematically higher relative to their dietary levels, ~~very~~ good agreement was seen between the two metrics. The regression co-efficients obtained from this analysis ~~was used to~~ informed the Bayesian hierarchical ~~imputation~~ model of the relationship between the two metrics. Adding a term to identify the survey sites generating the outlying points increased the r^2 to 0.79 but it was not retained because this term did not correspond to a generic survey characteristic that could be used in predictions outside the cross-walk dataset. The wider uncertainty bounds for the modeled relationship in the upper part of its range reflect the influence of the outliers.

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Figure 3. Sodium intakes in g/d by age, for regions and globally, both sexes combined, 2010

Figure 4. Mean (95% uncertainty interval) sodium intakes (g/d) in 2010 in 21 GBD regions

[Footnote] Regions are ranked by levels in both sexes combined, ages 20+. Intakes are not age-standardised.

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Figure 5. Mean (95% uncertainty interval) age-standardised sodium intakes (g/d) in 1990 and 2010 in 21 GBD regions

[Footnote] The upper symbol for each pair is for 2010. Regions are ranked by levels in both sexes combined, ages 20+.

Figure 6. Sodium intakes by country, for ages 20+, average of both sexes, in 2010. Panel (a) presents mean intakes in g/d; panel (b) presents relative uncertainty*

[~~Foonote~~Footnote] *Monte Carlo standard errors divided by the mean of these intake estimates.

Supplementary Materials

Methods Supplement: The ~~imputation~~ estimation model,~~:~~ DisM~~m~~od~~- II~~MR

With associated figures

Figure S1. Guide to model outputs for regions

Figure S2. Model output for regions (1)

Figure S3. Model output for regions (2)

Figure S4. Model output for regions (3)

Figure S5. Model output for regions (4)

Supplementary Table. Surveys and survey pairs used in the assessment of sodium exposure with identification of sources for published reports and of corresponding members where data was provided on request.

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Table 1. Classification of 245 surveys of sodium intake by exposure metric reported, period of survey and national representativeness, with pairs of surveys reporting in both metrics identified.

	Surveys (n=245)		Survey characteristics (n=219 counting survey pairs as 1)						
			Contributing surveys and survey pairs by metric				Period		
GBD Region (*=high income)	Urine-based	Diet-based	Urine-based only	Diet-based only	Both (survey pairs)[†]	Total	1980-1998	1999-2010	Nationally represent-ative
Asia, Central	1	0	1	0	0	1	1	0	1 (100%)
Asia, East	11	15	8	12	3	23	21	2	3 (13%)
Asia Pacific High Income*	12	11	7	5	6	18	14	4	4 (22%)
Asia, South	2	4	2	4	0	6	3	3	0 (0%)
Asia, Southeast	2	3	2	3	0	5	2	3	2 (40%)
Australasia*	8	1	8	1	0	9	6	3	1 (11%)
Caribbean	5	2	5	2	0	7	6	1	2 (29%)
Europe, Central	4	2	4	2	0	6	2	4	3 (50%)
Europe, Eastern	1	1	1	1	0	2	2	0	1 (50%)
Europe, Western*	51	31	46	27	4	77	45	32	27 (35%)
Latin America, Andean	0	0	0	0	0	0	0	0	NA
Latin America, Central	3	1	3	1	0	4	3	1	1 (25%)
Latin America, Southern	1	1	1	1	0	2	1	1	1 (50%)
Latin America, Tropical	0	2	0	2	0	2	0	2	1 (50%)
North America, High Income*	21	14	11	4	10	25	20	5	4 (16%)
North Africa Middle East	2	7	2	7	0	9	2	7	4 (44%)
Oceania	1	2	1	2	0	3	3	0	3 (100%)
Sub-Saharan Africa, East	3	2	3	2	0	5	5	0	0 (0%)
Sub-Saharan Africa, Central	0	0	0	0	0	0	0	0	NA
Sub-Saharan Africa, Southern	7	4	4	1	3	8	4	4	1 (13%)
Sub-Saharan Africa, West	7	0	7	0	0	7	5	2	0 (0%)
Total	142	103	116	77	26[†]	219	145	74	55 (35%[‡])

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† These 26 surveys with measurements in both metrics reported on all subjects provided the 79 paired urine-diet datapoints that were used to estimate the relationship between the 2 metrics (Figure 2); the diet-based datapoints from these 26 surveys were not subsequently used in the final ~~imputation~~ estimation model.

‡ Unweighted mean for 19 regions with at least 1 survey

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Table 2. Age-standardised estimated sodium intakes (g/d) in 1990 and 2010, persons aged 20 and over, by country (95% uncertainty intervals).

	Total		Males		Females	
	1990	2010	1990	2010	1990	2010
Afghanistan	3.29 (2.71-3.95)	3.39 (2.79-4.06)	3.44 (2.61-4.46)	3.55 (2.63-4.69)	3.12 (2.36-4.06)	3.22 (2.42-4.17)
Albania	3.47 (2.89-4.16)	3.67 (3.05-4.34)	3.64 (2.83-4.62)	3.86 (2.98-5.00)	3.31 (2.56-4.29)	3.48 (2.67-4.37)
Algeria	3.91 (3.32-4.59)	4.28 (3.59-5.00)	4.09 (3.19-5.17)	4.51 (3.50-5.72)	3.73 (2.97-4.74)	4.07 (3.20-5.08)
Andorra	3.56 (3.04-4.16)	3.81 (3.21-4.44)	3.85 (3.05-4.83)	4.01 (3.19-5.07)	3.29 (2.59-4.05)	3.61 (2.84-4.53)
Angola	2.46 (2.07-2.90)	2.49 (2.06-2.97)	2.58 (2.03-3.28)	2.61 (2.02-3.35)	2.35 (1.82-2.94)	2.38 (1.86-3.07)
Antigua and Barbuda	2.71 (2.28-3.23)	2.67 (2.23-3.18)	2.85 (2.19-3.64)	2.81 (2.18-3.55)	2.58 (2.01-3.26)	2.54 (1.98-3.24)
Argentina	3.01 (2.93-3.10)	3.00 (2.92-3.08)	3.16 (3.03-3.29)	3.15 (3.03-3.26)	2.87 (2.76-2.99)	2.87 (2.76-2.98)
Armenia	4.84 (4.04-5.67)	4.92 (4.13-5.77)	5.07 (4.03-6.31)	5.19 (4.06-6.57)	4.65 (3.64-5.86)	4.71 (3.69-5.89)
Australia	3.38 (3.26-3.50)	3.42 (3.29-3.55)	3.55 (3.37-3.75)	3.59 (3.39-3.77)	3.22 (3.05-3.40)	3.26 (3.09-3.42)
Austria	3.89 (3.57-4.22)	3.95 (3.63-4.31)	4.20 (3.73-4.73)	4.16 (3.70-4.64)	3.60 (3.22-4.06)	3.76 (3.29-4.28)
Azerbaijan	4.55 (3.83-5.34)	5.06 (4.31-5.98)	4.79 (3.74-6.08)	5.31 (4.18-6.71)	4.35 (3.44-5.56)	4.85 (3.83-6.13)
Bahamas	3.03 (2.53-3.60)	2.99 (2.48-3.54)	3.18 (2.41-4.10)	3.13 (2.41-3.97)	2.89 (2.24-3.65)	2.86 (2.22-3.67)
Bahrain	4.40 (4.03-4.82)	5.38 (4.85-5.91)	4.56 (4.05-5.11)	5.57 (4.88-6.31)	4.15 (3.68-4.69)	5.05 (4.42-5.72)
Bangladesh	3.68 (3.09-4.41)	3.54 (2.98-4.21)	3.84 (3.02-4.93)	3.71 (2.89-4.67)	3.51 (2.76-4.41)	3.38 (2.63-4.32)
Barbados	3.40 (3.12-3.69)	3.42 (3.11-3.76)	3.56 (3.17-3.99)	3.59 (3.12-4.09)	3.25 (2.87-3.65)	3.25 (2.85-3.69)
Belarus	4.00 (3.39-4.72)	4.35 (3.69-5.16)	4.19 (3.28-5.22)	4.55 (3.55-5.69)	3.83 (2.98-4.72)	4.17 (3.27-5.24)
Belgium	3.48 (3.30-3.67)	3.45 (3.23-3.68)	3.76 (3.48-4.05)	3.64 (3.32-3.96)	3.21 (2.98-3.46)	3.27 (2.98-3.60)
Belize	2.67 (2.38-3.02)	2.62 (2.34-2.93)	2.80 (2.38-3.29)	2.75 (2.31-3.21)	2.55 (2.17-3.01)	2.50 (2.10-2.93)
Benin	2.86 (2.53-3.28)	2.85 (2.49-3.22)	3.01 (2.50-3.57)	2.97 (2.47-3.52)	2.73 (2.27-3.26)	2.73 (2.28-3.25)
Bhutan	3.72 (3.13-4.33)	3.64 (3.07-4.24)	3.88 (3.05-4.86)	3.80 (2.97-4.78)	3.55 (2.82-4.46)	3.45 (2.74-4.26)
Bolivia, Plurinational State of	3.51 (2.97-4.11)	3.59 (3.02-4.20)	3.67 (2.90-4.54)	3.77 (3.01-4.69)	3.35 (2.63-4.16)	3.41 (2.71-4.30)
Bosnia and Herzegovina	3.26 (2.71-3.93)	3.46 (2.88-4.15)	3.43 (2.62-4.41)	3.62 (2.78-4.59)	3.10 (2.38-4.07)	3.32 (2.58-4.25)
Botswana	2.49 (2.07-2.95)	2.53 (2.15-2.97)	2.63 (2.05-3.33)	2.66 (2.06-3.30)	2.37 (1.85-2.97)	2.40 (1.90-3.00)
Brazil	3.89 (3.78-3.99)	4.11 (4.01-4.22)	4.08 (3.93-4.23)	4.31 (4.17-4.46)	3.70 (3.57-3.83)	3.92 (3.79-4.07)
Brunei Darussalam	4.40 (3.70-5.13)	4.42 (3.71-5.16)	4.59 (3.62-5.73)	4.62 (3.59-5.83)	4.18 (3.27-5.24)	4.21 (3.27-5.30)
Bulgaria	3.63 (3.40-3.85)	3.62 (3.39-3.87)	3.82 (3.48-4.17)	3.80 (3.45-4.18)	3.45 (3.14-3.78)	3.45 (3.13-3.79)
Burkina Faso	2.91 (2.46-3.46)	2.88 (2.40-3.41)	3.07 (2.41-3.91)	3.04 (2.38-3.80)	2.77 (2.15-3.53)	2.74 (2.11-3.47)
Burundi	1.62 (1.31-1.99)	1.73 (1.42-2.09)	1.70 (1.25-2.26)	1.82 (1.38-2.36)	1.56 (1.14-2.07)	1.65 (1.23-2.15)
Cambodia	4.54 (3.81-5.38)	4.41 (3.73-5.18)	4.76 (3.69-6.07)	4.65 (3.68-5.87)	4.37 (3.41-5.52)	4.20 (3.26-5.24)
Cameroon	2.07 (1.82-2.35)	2.09 (1.84-2.36)	2.18 (1.81-2.59)	2.19 (1.81-2.58)	1.97 (1.64-2.32)	1.99 (1.68-2.38)

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Canada	3.55 (3.45-3.66)	3.71 (3.58-3.83)	3.74 (3.58-3.90)	3.88 (3.69-4.08)	3.37 (3.22-3.52)	3.53 (3.36-3.70)
Cape Verde	2.99 (2.55-3.51)	3.25 (2.74-3.89)	3.16 (2.47-3.92)	3.42 (2.63-4.33)	2.87 (2.21-3.63)	3.10 (2.39-3.86)
Central African Republic	2.75 (2.32-3.25)	2.80 (2.33-3.29)	2.89 (2.24-3.62)	2.94 (2.30-3.71)	2.62 (2.06-3.27)	2.66 (2.05-3.37)
Chad	2.87 (2.42-3.38)	2.87 (2.43-3.37)	3.00 (2.33-3.78)	3.02 (2.37-3.76)	2.74 (2.12-3.38)	2.72 (2.15-3.39)
Chile	2.79 (2.38-3.29)	2.80 (2.35-3.31)	2.92 (2.30-3.74)	2.92 (2.29-3.70)	2.67 (2.11-3.37)	2.69 (2.13-3.36)
China	4.42 (4.24-4.63)	4.83 (4.62-5.05)	4.63 (4.35-4.93)	5.05 (4.71-5.39)	4.20 (3.94-4.49)	4.60 (4.31-4.88)
Colombia	4.12 (3.77-4.45)	4.09 (3.77-4.43)	4.31 (3.82-4.83)	4.29 (3.83-4.81)	3.93 (3.50-4.43)	3.91 (3.48-4.36)
Comoros	1.69 (1.42-2.02)	1.67 (1.41-1.98)	1.78 (1.39-2.26)	1.74 (1.35-2.22)	1.61 (1.22-2.04)	1.59 (1.24-2.03)
Congo	2.30 (1.95-2.70)	2.25 (1.88-2.67)	2.42 (1.89-3.05)	2.35 (1.83-2.97)	2.18 (1.69-2.73)	2.15 (1.63-2.78)
Congo, the Democratic Republic of the	2.27 (1.90-2.66)	2.42 (2.05-2.84)	2.39 (1.84-2.95)	2.54 (1.97-3.24)	2.16 (1.68-2.74)	2.31 (1.82-2.90)
Costa Rica	2.98 (2.51-3.50)	3.18 (2.71-3.73)	3.13 (2.49-3.91)	3.32 (2.56-4.18)	2.83 (2.20-3.56)	3.03 (2.40-3.76)
Côte dIvoire	2.78 (2.48-3.13)	2.80 (2.50-3.13)	2.90 (2.45-3.42)	2.94 (2.48-3.45)	2.64 (2.22-3.11)	2.65 (2.25-3.11)
Croatia	3.25 (2.73-3.81)	3.71 (3.15-4.34)	3.42 (2.70-4.28)	3.88 (3.04-4.80)	3.10 (2.44-3.92)	3.54 (2.80-4.45)
Cuba	2.80 (2.36-3.29)	2.64 (2.23-3.12)	2.94 (2.32-3.67)	2.75 (2.16-3.46)	2.66 (2.07-3.27)	2.52 (1.99-3.21)
Cyprus	3.76 (3.17-4.45)	4.06 (3.41-4.76)	4.05 (3.18-5.12)	4.29 (3.26-5.36)	3.49 (2.71-4.39)	3.83 (3.03-4.81)
Czech Republic	3.74 (3.16-4.44)	3.98 (3.37-4.74)	3.97 (3.14-5.02)	4.17 (3.31-5.31)	3.53 (2.75-4.36)	3.80 (3.00-4.75)
Denmark	3.53 (3.23-3.82)	3.27 (2.98-3.58)	3.80 (3.36-4.29)	3.43 (3.00-3.88)	3.26 (2.87-3.67)	3.11 (2.72-3.55)
Djibouti	2.29 (1.90-2.72)	2.36 (1.94-2.81)	2.39 (1.85-3.07)	2.48 (1.91-3.14)	2.19 (1.67-2.81)	2.24 (1.74-2.84)
Dominica	2.62 (2.21-3.10)	2.69 (2.30-3.20)	2.74 (2.14-3.44)	2.82 (2.13-3.60)	2.51 (1.96-3.22)	2.57 (1.96-3.29)
Dominican Republic	2.45 (2.08-2.85)	2.60 (2.21-3.03)	2.57 (2.01-3.26)	2.70 (2.14-3.38)	2.32 (1.83-2.86)	2.50 (1.99-3.12)
Ecuador	2.88 (2.41-3.38)	3.03 (2.55-3.57)	3.00 (2.37-3.76)	3.17 (2.47-4.01)	2.76 (2.16-3.45)	2.88 (2.29-3.66)
Egypt	3.63 (3.10-4.22)	3.68 (3.13-4.32)	3.81 (3.01-4.75)	3.85 (3.00-4.82)	3.45 (2.75-4.33)	3.52 (2.77-4.36)
El Salvador	3.19 (2.64-3.79)	3.19 (2.71-3.71)	3.35 (2.60-4.28)	3.36 (2.63-4.22)	3.04 (2.37-3.85)	3.05 (2.39-3.81)
Equatorial Guinea	2.50 (2.12-3.00)	2.30 (1.90-2.78)	2.61 (2.07-3.24)	2.40 (1.80-3.08)	2.37 (1.89-3.04)	2.20 (1.67-2.90)
Eritrea	2.32 (1.93-2.73)	2.37 (2.00-2.82)	2.43 (1.88-3.11)	2.50 (1.96-3.18)	2.22 (1.71-2.78)	2.25 (1.76-2.83)
Estonia	3.49 (3.30-3.69)	3.95 (3.69-4.23)	3.67 (3.40-3.96)	4.15 (3.76-4.56)	3.33 (3.07-3.60)	3.77 (3.43-4.16)
Ethiopia	2.30 (1.92-2.70)	2.27 (1.95-2.67)	2.42 (1.87-3.07)	2.38 (1.87-2.97)	2.19 (1.72-2.74)	2.17 (1.72-2.71)
Fiji	2.86 (2.41-3.35)	2.87 (2.41-3.41)	2.99 (2.34-3.76)	3.01 (2.36-3.84)	2.73 (2.16-3.42)	2.74 (2.13-3.43)
Finland	3.73 (3.52-3.95)	3.85 (3.63-4.07)	4.02 (3.70-4.39)	4.05 (3.72-4.40)	3.44 (3.16-3.74)	3.65 (3.35-3.94)
France	3.70 (3.52-3.91)	3.77 (3.58-3.97)	4.00 (3.72-4.30)	3.96 (3.66-4.28)	3.41 (3.17-3.65)	3.58 (3.31-3.86)
Gabon	1.93 (1.58-2.36)	2.01 (1.63-2.45)	2.02 (1.53-2.62)	2.09 (1.55-2.76)	1.83 (1.39-2.35)	1.92 (1.42-2.54)
Gambia	3.04 (2.58-3.61)	3.07 (2.59-3.58)	3.18 (2.51-4.05)	3.22 (2.56-4.06)	2.88 (2.24-3.63)	2.93 (2.27-3.73)
Georgia	4.73 (3.95-5.60)	5.30 (4.49-6.26)	4.95 (3.94-6.29)	5.57 (4.44-7.03)	4.53 (3.55-5.72)	5.07 (3.96-6.29)
Germany	3.45 (3.24-3.68)	3.54 (3.36-3.73)	3.73 (3.42-4.07)	3.72 (3.43-4.02)	3.18 (2.91-3.47)	3.36 (3.13-3.61)
Ghana	2.44 (2.19-2.73)	2.35 (2.09-2.61)	2.56 (2.19-2.98)	2.45 (2.09-2.88)	2.32 (2.02-2.71)	2.24 (1.89-2.62)
Greece	3.55 (2.92-4.25)	3.77 (3.16-4.52)	3.82 (2.92-4.91)	3.97 (3.11-5.03)	3.29 (2.53-4.27)	3.58 (2.76-4.53)

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Grenada	2.44 (2.07-2.85)	2.61 (2.20-3.09)	2.55 (2.02-3.21)	2.73 (2.14-3.48)	2.33 (1.83-2.91)	2.48 (1.92-3.18)
Guatemala	2.86 (2.52-3.22)	2.94 (2.60-3.28)	2.99 (2.50-3.53)	3.08 (2.59-3.63)	2.73 (2.31-3.19)	2.81 (2.38-3.29)
Guinea	2.71 (2.29-3.22)	2.77 (2.33-3.26)	2.84 (2.23-3.58)	2.92 (2.30-3.64)	2.59 (2.04-3.27)	2.62 (2.06-3.25)
Guinea-Bissau	2.94 (2.48-3.48)	3.03 (2.55-3.61)	3.09 (2.44-3.87)	3.17 (2.49-4.09)	2.80 (2.23-3.50)	2.90 (2.25-3.66)
Guyana	2.36 (1.98-2.78)	2.45 (2.05-2.93)	2.47 (1.91-3.14)	2.56 (2.02-3.30)	2.26 (1.78-2.88)	2.34 (1.82-2.98)
Haiti	2.43 (2.02-2.86)	2.66 (2.23-3.15)	2.56 (2.00-3.14)	2.78 (2.17-3.50)	2.31 (1.79-2.94)	2.54 (1.98-3.26)
Honduras	2.88 (2.42-3.41)	2.95 (2.49-3.48)	3.02 (2.40-3.75)	3.07 (2.38-3.88)	2.75 (2.11-3.49)	2.84 (2.24-3.55)
Hungary	4.28 (3.90-4.67)	4.23 (3.87-4.57)	4.50 (3.94-5.13)	4.43 (3.91-4.95)	4.07 (3.57-4.62)	4.04 (3.60-4.50)
Iceland	3.53 (3.15-3.90)	3.58 (3.24-3.97)	3.79 (3.23-4.33)	3.77 (3.22-4.34)	3.25 (2.78-3.78)	3.38 (2.92-3.90)
India	3.78 (3.69-3.87)	3.72 (3.63-3.82)	3.95 (3.82-4.07)	3.88 (3.73-4.02)	3.61 (3.49-3.73)	3.56 (3.44-3.68)
Indonesia	3.43 (3.07-3.82)	3.36 (3.02-3.76)	3.59 (3.09-4.18)	3.53 (3.02-4.09)	3.28 (2.82-3.81)	3.21 (2.77-3.75)
Iran, Islamic Republic of	3.85 (3.46-4.27)	4.02 (3.64-4.44)	4.03 (3.46-4.64)	4.21 (3.65-4.85)	3.67 (3.17-4.20)	3.83 (3.33-4.37)
Iraq	3.46 (2.94-4.09)	3.76 (3.19-4.46)	3.64 (2.86-4.61)	3.95 (3.12-5.00)	3.30 (2.63-4.18)	3.59 (2.85-4.51)
Ireland	3.61 (3.24-4.06)	3.74 (3.35-4.18)	3.91 (3.35-4.57)	3.93 (3.38-4.58)	3.32 (2.84-3.85)	3.55 (3.01-4.14)
Israel	3.68 (3.20-4.17)	3.79 (3.27-4.37)	3.97 (3.21-4.81)	4.00 (3.20-4.91)	3.40 (2.79-4.08)	3.59 (2.91-4.32)
Italy	4.31 (4.11-4.51)	4.42 (4.22-4.61)	4.65 (4.30-4.98)	4.65 (4.34-4.96)	3.99 (3.72-4.26)	4.19 (3.92-4.45)
Jamaica	1.90 (1.76-2.06)	1.92 (1.77-2.08)	2.00 (1.81-2.22)	2.01 (1.79-2.26)	1.82 (1.63-2.03)	1.84 (1.63-2.06)
Japan	4.71 (4.54-4.89)	4.89 (4.71-5.08)	4.93 (4.67-5.19)	5.12 (4.85-5.41)	4.50 (4.27-4.75)	4.68 (4.43-4.93)
Jordan	3.54 (3.00-4.19)	4.13 (3.47-4.87)	3.69 (2.93-4.62)	4.31 (3.41-5.48)	3.38 (2.67-4.19)	3.95 (3.04-5.00)
Kazakhstan	4.92 (4.17-5.74)	5.98 (5.07-7.14)	5.16 (4.07-6.41)	6.31 (4.95-7.98)	4.72 (3.66-5.84)	5.70 (4.47-7.21)
Kenya	1.43 (1.30-1.58)	1.48 (1.34-1.62)	1.50 (1.29-1.71)	1.55 (1.34-1.77)	1.37 (1.19-1.58)	1.41 (1.22-1.60)
Kiribati	2.18 (1.80-2.65)	2.22 (1.82-2.68)	2.27 (1.72-2.97)	2.31 (1.72-3.05)	2.07 (1.59-2.70)	2.14 (1.60-2.79)
Korea, Democratic ~~Peoples~~People's Republic of	3.34 (2.75-3.95)	3.79 (3.16-4.46)	3.49 (2.70-4.39)	4.01 (3.07-5.21)	3.20 (2.46-4.03)	3.59 (2.79-4.55)
Korea, Republic of	4.92 (4.68-5.17)	5.21 (4.98-5.48)	5.15 (4.79-5.52)	5.46 (5.12-5.81)	4.70 (4.39-5.04)	4.98 (4.66-5.32)
Kuwait	3.66 (3.31-4.05)	3.88 (3.46-4.31)	3.81 (3.32-4.36)	4.01 (3.45-4.60)	3.46 (3.02-3.95)	3.65 (3.13-4.19)
Kyrgyzstan	5.09 (4.29-5.98)	5.38 (4.55-6.32)	5.34 (4.30-6.64)	5.64 (4.43-7.12)	4.88 (3.79-6.04)	5.14 (4.08-6.41)
Lao Peoples Democratic Republic	4.58 (3.80-5.44)	4.45 (3.75-5.27)	4.78 (3.83-6.02)	4.69 (3.63-5.98)	4.39 (3.43-5.53)	4.23 (3.31-5.36)
Latvia	3.58 (3.03-4.24)	4.19 (3.57-5.01)	3.75 (2.97-4.74)	4.37 (3.41-5.45)	3.43 (2.74-4.30)	4.02 (3.20-5.08)
Lebanon	2.60 (2.34-2.88)	3.13 (2.78-3.54)	2.72 (2.32-3.15)	3.30 (2.75-3.89)	2.50 (2.13-2.91)	2.98 (2.49-3.52)
Lesotho	2.66 (2.18-3.14)	2.62 (2.21-3.11)	2.79 (2.13-3.56)	2.76 (2.16-3.49)	2.55 (1.94-3.23)	2.50 (1.92-3.18)
Liberia	2.64 (2.23-3.14)	2.68 (2.23-3.17)	2.76 (2.12-3.49)	2.82 (2.20-3.60)	2.52 (2.01-3.17)	2.55 (1.96-3.26)
Libyan Arab Jamahiriya	3.74 (3.14-4.45)	4.24 (3.55-5.01)	3.90 (3.06-4.97)	4.45 (3.50-5.60)	3.54 (2.76-4.50)	4.03 (3.15-5.08)
Lithuania	3.60 (3.04-4.27)	4.07 (3.47-4.74)	3.77 (3.00-4.64)	4.27 (3.44-5.38)	3.45 (2.73-4.34)	3.90 (3.06-4.79)
Luxembourg	3.87 (3.29-4.56)	4.07 (3.42-4.82)	4.18 (3.27-5.20)	4.28 (3.36-5.37)	3.57 (2.81-4.60)	3.85 (2.99-4.88)
Macedonia, the former Yugoslav Republic of	3.30 (2.77-3.90)	3.91 (3.31-4.55)	3.48 (2.75-4.47)	4.10 (3.21-5.09)	3.13 (2.47-3.98)	3.72 (2.93-4.64)
Madagascar	2.15 (1.83-2.59)	2.20 (1.85-2.58)	2.25 (1.75-2.86)	2.31 (1.81-2.88)	2.05 (1.61-2.61)	2.09 (1.65-2.65)

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Malawi	1.63 (1.45-1.83)	1.66 (1.47-1.86)	1.71 (1.45-2.00)	1.73 (1.46-2.03)	1.56 (1.32-1.84)	1.58 (1.33-1.86)
Malaysia	3.42 (3.11-3.76)	3.57 (3.25-3.93)	3.57 (3.12-4.07)	3.74 (3.29-4.29)	3.27 (2.86-3.75)	3.40 (2.95-3.87)
Maldives	3.68 (3.00-4.49)	3.31 (2.58-4.17)	3.84 (2.77-5.05)	3.47 (2.37-4.88)	3.50 (2.56-4.65)	3.14 (2.18-4.26)
Mali	3.21 (2.71-3.74)	3.15 (2.67-3.76)	3.38 (2.69-4.28)	3.31 (2.57-4.20)	3.05 (2.38-3.86)	3.01 (2.35-3.80)
Malta	3.88 (3.53-4.25)	4.10 (3.74-4.50)	4.19 (3.66-4.75)	4.31 (3.78-4.89)	3.58 (3.14-4.03)	3.90 (3.44-4.45)
Marshall Islands	2.49 (2.11-2.94)	2.55 (2.15-3.01)	2.60 (2.05-3.31)	2.68 (2.12-3.40)	2.37 (1.87-3.00)	2.43 (1.88-3.05)
Mauritania	3.10 (2.61-3.69)	2.97 (2.49-3.48)	3.25 (2.53-4.15)	3.12 (2.43-3.99)	2.96 (2.32-3.75)	2.84 (2.21-3.57)
Mauritius	5.05 (4.23-5.93)	5.45 (4.57-6.50)	5.28 (4.10-6.65)	5.71 (4.40-7.28)	4.83 (3.77-6.20)	5.20 (4.06-6.60)
Mexico	2.71 (2.54-2.90)	2.76 (2.57-2.94)	2.85 (2.59-3.14)	2.89 (2.62-3.17)	2.58 (2.35-2.85)	2.63 (2.39-2.89)
Micronesia, Federated States of	2.51 (2.11-2.94)	2.56 (2.17-3.03)	2.62 (2.06-3.29)	2.68 (2.12-3.37)	2.39 (1.84-3.00)	2.44 (1.88-3.04)
Moldova, Republic of	3.59 (3.03-4.31)	3.95 (3.32-4.65)	3.80 (3.00-4.81)	4.13 (3.27-5.28)	3.41 (2.72-4.29)	3.79 (2.93-4.79)
Mongolia	5.18 (4.90-5.46)	5.14 (4.84-5.43)	5.43 (5.02-5.86)	5.38 (4.95-5.84)	4.94 (4.60-5.31)	4.91 (4.54-5.33)
Montenegro	3.15 (2.63-3.72)	3.63 (3.08-4.23)	3.31 (2.59-4.16)	3.81 (3.03-4.79)	2.99 (2.33-3.75)	3.45 (2.76-4.30)
Morocco	3.96 (3.34-4.66)	4.31 (3.67-5.06)	4.17 (3.28-5.21)	4.53 (3.55-5.78)	3.77 (2.97-4.65)	4.11 (3.24-5.12)
Mozambique	2.13 (1.79-2.51)	2.24 (1.86-2.65)	2.24 (1.75-2.84)	2.36 (1.85-2.98)	2.04 (1.60-2.57)	2.13 (1.67-2.75)
Myanmar	4.56 (3.81-5.37)	4.49 (3.75-5.29)	4.77 (3.68-5.99)	4.71 (3.63-5.96)	4.36 (3.43-5.56)	4.27 (3.36-5.36)
Namibia	2.59 (2.20-3.05)	2.64 (2.24-3.09)	2.72 (2.10-3.43)	2.78 (2.17-3.43)	2.47 (1.92-3.12)	2.51 (2.00-3.15)
Nepal	3.87 (3.27-4.57)	3.89 (3.30-4.59)	4.06 (3.22-5.09)	4.07 (3.23-5.20)	3.69 (2.89-4.63)	3.73 (2.89-4.61)
Netherlands	3.44 (3.25-3.65)	3.32 (3.10-3.56)	3.72 (3.44-4.02)	3.50 (3.17-3.84)	3.17 (2.93-3.46)	3.15 (2.87-3.45)
New Zealand	3.27 (3.15-3.41)	3.47 (3.33-3.63)	3.44 (3.25-3.64)	3.65 (3.43-3.89)	3.12 (2.94-3.30)	3.31 (3.11-3.51)
Nicaragua	3.15 (2.65-3.78)	3.22 (2.72-3.83)	3.30 (2.56-4.22)	3.37 (2.57-4.26)	3.00 (2.33-3.83)	3.09 (2.41-3.88)
Niger	3.11 (2.60-3.66)	2.92 (2.48-3.44)	3.24 (2.54-4.04)	3.05 (2.37-3.82)	2.98 (2.32-3.74)	2.79 (2.17-3.47)
Nigeria	2.81 (2.50-3.17)	2.82 (2.51-3.17)	2.94 (2.51-3.45)	2.96 (2.52-3.48)	2.69 (2.29-3.18)	2.69 (2.30-3.17)
Norway	3.67 (3.10-4.36)	3.80 (3.24-4.49)	3.96 (3.10-4.96)	4.01 (3.15-5.06)	3.38 (2.63-4.18)	3.58 (2.77-4.51)
Oman	3.37 (2.81-4.01)	3.78 (3.17-4.46)	3.50 (2.70-4.38)	3.93 (3.08-4.93)	3.18 (2.50-4.00)	3.56 (2.82-4.46)
Pakistan	4.03 (3.42-4.73)	3.91 (3.32-4.66)	4.20 (3.31-5.24)	4.05 (3.18-5.14)	3.83 (3.01-4.75)	3.75 (2.97-4.77)
Palestinian Territory, Occupied	3.31 (2.77-3.93)	3.86 (3.24-4.57)	3.47 (2.72-4.48)	4.04 (3.16-5.13)	3.15 (2.45-3.96)	3.69 (2.87-4.65)
Panama	3.35 (2.84-4.00)	3.39 (2.89-3.98)	3.52 (2.82-4.42)	3.54 (2.79-4.55)	3.18 (2.51-3.99)	3.25 (2.54-4.03)
Papua New Guinea	2.45 (2.04-2.91)	2.45 (2.07-2.86)	2.57 (2.01-3.27)	2.58 (2.01-3.22)	2.32 (1.79-2.93)	2.33 (1.83-2.91)
Paraguay	4.01 (3.38-4.76)	4.31 (3.66-5.09)	4.23 (3.32-5.41)	4.52 (3.55-5.69)	3.80 (3.00-4.72)	4.10 (3.21-5.17)
Peru	3.05 (2.57-3.62)	3.07 (2.58-3.60)	3.20 (2.49-4.08)	3.22 (2.53-4.03)	2.91 (2.23-3.70)	2.91 (2.31-3.69)
Philippines	4.22 (3.55-4.99)	4.29 (3.65-5.10)	4.39 (3.44-5.50)	4.49 (3.50-5.68)	4.05 (3.19-5.09)	4.10 (3.20-5.29)
Poland	3.82 (3.57-4.07)	3.84 (3.61-4.06)	4.02 (3.67-4.40)	4.03 (3.68-4.38)	3.63 (3.29-3.98)	3.66 (3.37-4.00)
Portugal	3.88 (3.64-4.13)	4.24 (3.98-4.51)	4.20 (3.83-4.60)	4.46 (4.07-4.89)	3.58 (3.26-3.93)	4.03 (3.68-4.41)
Qatar	3.53 (2.87-4.28)	4.21 (3.34-5.17)	3.61 (2.78-4.55)	4.29 (3.25-5.44)	3.30 (2.59-4.27)	3.90 (2.98-5.04)
Romania	3.77 (3.21-4.43)	4.12 (3.46-4.83)	3.97 (3.11-4.99)	4.32 (3.42-5.43)	3.58 (2.85-4.41)	3.92 (3.08-4.93)

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Russian Federation	3.72 (3.53-3.93)	4.17 (3.95-4.40)	3.91 (3.64-4.24)	4.38 (4.07-4.72)	3.56 (3.29-3.84)	3.99 (3.69-4.29)
Rwanda	1.52 (1.23-1.88)	1.60 (1.31-1.95)	1.59 (1.18-2.11)	1.67 (1.25-2.14)	1.45 (1.07-1.91)	1.53 (1.12-2.03)
Saint Lucia	2.84 (2.54-3.15)	2.93 (2.58-3.30)	2.98 (2.56-3.43)	3.08 (2.60-3.60)	2.72 (2.32-3.16)	2.80 (2.34-3.31)
Saint Vincent and the Grenadines	2.70 (2.29-3.18)	2.82 (2.39-3.32)	2.83 (2.26-3.50)	2.94 (2.30-3.69)	2.58 (2.03-3.24)	2.70 (2.09-3.46)
Samoa	2.15 (1.97-2.36)	2.07 (1.82-2.34)	2.25 (1.99-2.56)	2.16 (1.82-2.57)	2.05 (1.80-2.31)	1.97 (1.66-2.32)
Sao Tome and Principe	2.37 (1.98-2.84)	2.36 (1.97-2.77)	2.48 (1.93-3.19)	2.47 (1.93-3.14)	2.26 (1.74-2.93)	2.25 (1.77-2.87)
Saudi Arabia	2.98 (2.47-3.54)	3.20 (2.63-3.78)	3.08 (2.41-3.92)	3.33 (2.54-4.15)	2.82 (2.17-3.65)	3.03 (2.36-3.90)
Senegal	2.98 (2.49-3.52)	3.15 (2.67-3.71)	3.11 (2.41-3.91)	3.32 (2.55-4.17)	2.85 (2.23-3.59)	2.99 (2.34-3.77)
Serbia	3.21 (2.69-3.79)	3.67 (3.05-4.39)	3.37 (2.67-4.18)	3.87 (2.94-4.95)	3.05 (2.35-3.88)	3.48 (2.68-4.40)
Seychelles	4.36 (3.63-5.20)	4.34 (3.62-5.12)	4.59 (3.54-5.84)	4.57 (3.55-5.74)	4.14 (3.18-5.21)	4.12 (3.21-5.17)
Sierra Leone	2.52 (2.10-2.99)	2.51 (2.11-2.94)	2.64 (2.09-3.34)	2.63 (2.05-3.25)	2.40 (1.88-3.03)	2.39 (1.89-2.96)
Singapore	5.03 (4.28-5.90)	5.14 (4.36-6.02)	5.25 (4.13-6.49)	5.37 (4.22-6.79)	4.81 (3.70-6.07)	4.92 (3.89-6.18)
Slovakia	3.64 (3.07-4.29)	4.23 (3.55-5.00)	3.82 (3.01-4.78)	4.46 (3.51-5.58)	3.48 (2.73-4.36)	4.02 (3.13-4.97)
Slovenia	3.87 (3.52-4.23)	4.23 (3.83-4.67)	4.07 (3.56-4.61)	4.43 (3.86-5.07)	3.68 (3.21-4.22)	4.02 (3.50-4.61)
Solomon Islands	2.26 (1.91-2.65)	2.33 (1.96-2.76)	2.37 (1.85-2.98)	2.44 (1.93-3.11)	2.14 (1.66-2.68)	2.22 (1.74-2.77)
Somalia	2.04 (1.71-2.42)	2.07 (1.77-2.43)	2.14 (1.67-2.69)	2.17 (1.74-2.71)	1.95 (1.53-2.45)	1.97 (1.53-2.51)
South Africa	2.41 (2.28-2.55)	2.48 (2.34-2.62)	2.53 (2.33-2.74)	2.61 (2.41-2.82)	2.30 (2.12-2.50)	2.37 (2.17-2.56)
Spain	3.72 (3.49-3.99)	4.02 (3.77-4.27)	4.01 (3.66-4.41)	4.24 (3.89-4.61)	3.44 (3.15-3.75)	3.81 (3.50-4.15)
Sri Lanka	3.92 (3.33-4.60)	3.87 (3.27-4.54)	4.10 (3.23-5.10)	4.07 (3.16-5.11)	3.75 (2.97-4.66)	3.69 (2.87-4.67)
Sudan	2.31 (1.96-2.71)	2.37 (2.01-2.79)	2.43 (1.92-3.02)	2.49 (1.93-3.17)	2.21 (1.74-2.79)	2.26 (1.77-2.82)
Suriname	2.66 (2.25-3.12)	2.89 (2.43-3.42)	2.79 (2.19-3.48)	3.03 (2.35-3.85)	2.53 (1.99-3.15)	2.76 (2.16-3.51)
Swaziland	2.63 (2.20-3.09)	2.53 (2.16-3.02)	2.77 (2.16-3.48)	2.67 (2.11-3.40)	2.52 (1.99-3.17)	2.42 (1.90-2.99)
Sweden	3.50 (3.32-3.70)	3.65 (3.46-3.85)	3.77 (3.50-4.05)	3.84 (3.56-4.15)	3.23 (3.01-3.47)	3.46 (3.22-3.71)
Switzerland	3.64 (3.41-3.89)	3.61 (3.40-3.85)	3.93 (3.60-4.29)	3.80 (3.48-4.13)	3.36 (3.08-3.67)	3.42 (3.13-3.74)
Syrian Arab Republic	3.80 (3.22-4.46)	4.18 (3.53-4.92)	3.97 (3.13-4.98)	4.37 (3.43-5.49)	3.64 (2.86-4.53)	3.99 (3.10-4.98)
Taiwan, Province of China	3.40 (3.12-3.69)	3.92 (3.66-4.17)	3.55 (3.14-3.99)	4.10 (3.72-4.48)	3.23 (2.85-3.61)	3.74 (3.40-4.11)
Tajikistan	5.03 (4.23-5.97)	5.40 (4.64-6.27)	5.29 (4.12-6.55)	5.70 (4.47-7.26)	4.79 (3.76-5.97)	5.13 (4.01-6.36)
Tanzania, United Republic of	2.81 (2.53-3.14)	2.75 (2.45-3.08)	2.94 (2.52-3.43)	2.88 (2.46-3.42)	2.69 (2.28-3.16)	2.62 (2.20-3.08)
Thailand	5.23 (4.82-5.66)	5.31 (4.88-5.75)	5.49 (4.94-6.15)	5.58 (4.97-6.18)	4.99 (4.46-5.58)	5.06 (4.54-5.65)
Timor-Leste	4.59 (3.83-5.38)	4.47 (3.71-5.32)	4.80 (3.78-5.98)	4.69 (3.61-5.91)	4.38 (3.45-5.56)	4.25 (3.39-5.37)
Togo	2.81 (2.40-3.33)	2.78 (2.36-3.34)	2.96 (2.29-3.82)	2.94 (2.30-3.77)	2.67 (2.12-3.35)	2.64 (2.09-3.29)
Tonga	2.61 (2.17-3.10)	2.73 (2.28-3.18)	2.72 (2.10-3.47)	2.88 (2.21-3.61)	2.50 (1.94-3.18)	2.58 (2.00-3.32)
Trinidad and Tobago	2.75 (2.51-3.01)	2.93 (2.63-3.23)	2.90 (2.55-3.28)	3.07 (2.64-3.56)	2.62 (2.30-2.95)	2.80 (2.43-3.19)
Tunisia	4.12 (3.51-4.91)	4.43 (3.72-5.23)	4.31 (3.37-5.44)	4.63 (3.61-5.83)	3.93 (3.09-4.91)	4.24 (3.32-5.34)
Turkey	3.76 (3.50-4.06)	4.10 (3.80-4.43)	3.94 (3.51-4.39)	4.30 (3.85-4.78)	3.59 (3.22-3.97)	3.91 (3.50-4.37)
Turkmenistan	5.10 (4.35-6.06)	5.43 (4.64-6.35)	5.35 (4.27-6.69)	5.69 (4.48-7.14)	4.87 (3.92-6.12)	5.20 (4.12-6.38)

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Uganda	1.95 (1.58-2.37)	2.11 (1.75-2.52)	2.05 (1.55-2.68)	2.21 (1.72-2.82)	1.86 (1.39-2.43)	2.00 (1.54-2.54)
Ukraine	3.85 (3.25-4.53)	4.19 (3.56-4.93)	4.05 (3.18-5.00)	4.41 (3.45-5.46)	3.68 (2.88-4.69)	4.01 (3.13-5.05)
United Arab Emirates	3.40 (2.73-4.16)	3.67 (2.97-4.47)	3.50 (2.64-4.48)	3.76 (2.92-4.78)	3.16 (2.38-4.12)	3.43 (2.65-4.39)
United Kingdom	3.48 (3.32-3.64)	3.61 (3.45-3.78)	3.75 (3.53-4.02)	3.80 (3.57-4.05)	3.21 (3.02-3.42)	3.42 (3.22-3.63)
United States	3.44 (3.35-3.53)	3.60 (3.50-3.70)	3.62 (3.48-3.77)	3.78 (3.63-3.93)	3.26 (3.14-3.40)	3.43 (3.29-3.56)
Uruguay	2.77 (2.34-3.27)	2.73 (2.32-3.18)	2.90 (2.24-3.65)	2.87 (2.27-3.58)	2.65 (2.09-3.35)	2.60 (2.05-3.28)
Uzbekistan	5.34 (4.50-6.25)	5.63 (4.83-6.53)	5.62 (4.47-6.93)	5.91 (4.67-7.41)	5.08 (4.04-6.39)	5.36 (4.28-6.66)
Vanuatu	2.17 (1.83-2.56)	2.24 (1.90-2.65)	2.26 (1.75-2.88)	2.33 (1.80-2.95)	2.07 (1.63-2.61)	2.14 (1.64-2.70)
Venezuela, Bolivarian Republic of	3.37 (2.84-3.92)	3.55 (3.01-4.18)	3.52 (2.81-4.39)	3.72 (2.92-4.66)	3.22 (2.52-3.98)	3.39 (2.65-4.21)
Viet Nam	4.48 (3.82-5.27)	4.59 (3.81-5.46)	4.67 (3.70-5.88)	4.83 (3.69-6.16)	4.31 (3.35-5.39)	4.37 (3.43-5.47)
Yemen	3.27 (2.76-3.86)	3.37 (2.82-4.05)	3.43 (2.65-4.38)	3.55 (2.74-4.53)	3.13 (2.46-3.94)	3.21 (2.48-4.13)
Zambia	2.27 (1.91-2.69)	2.27 (1.91-2.70)	2.39 (1.84-3.03)	2.38 (1.91-3.00)	2.15 (1.67-2.70)	2.17 (1.70-2.71)
Zimbabwe	3.06 (2.82-3.29)	3.10 (2.81-3.39)	3.21 (2.85-3.59)	3.25 (2.83-3.66)	2.92 (2.59-3.23)	2.95 (2.58-3.39)

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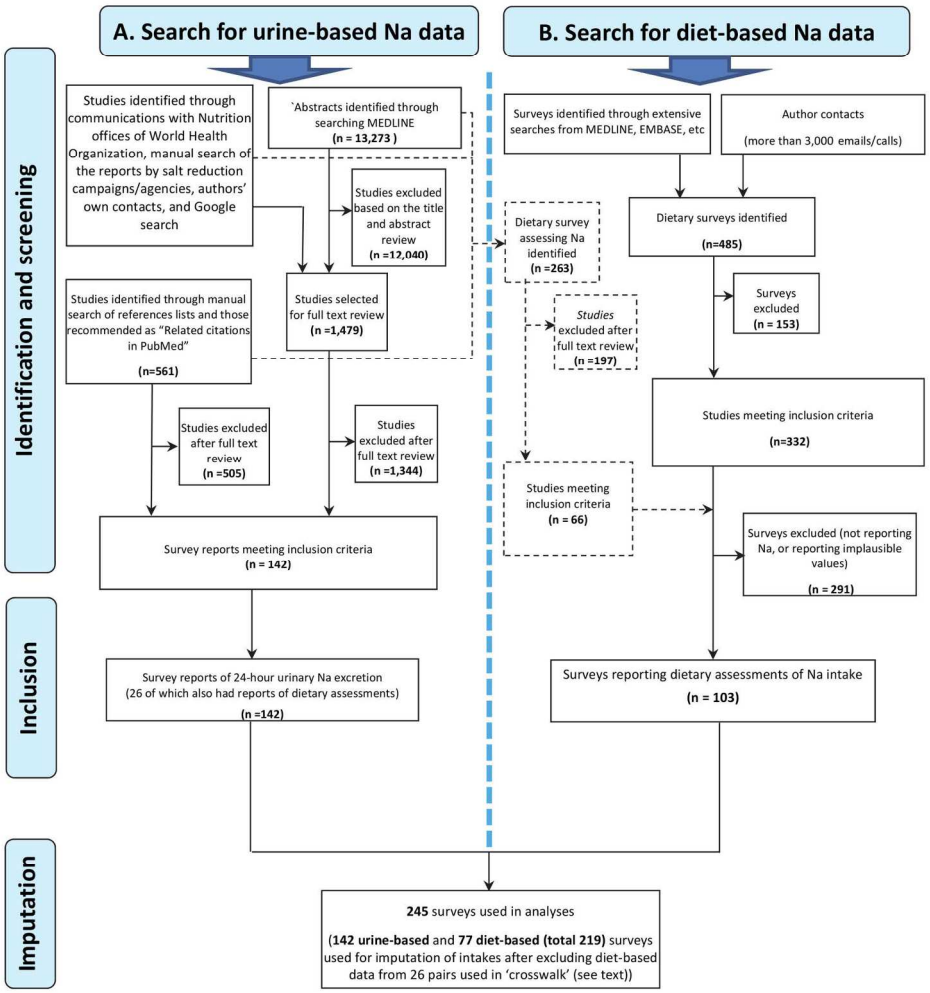

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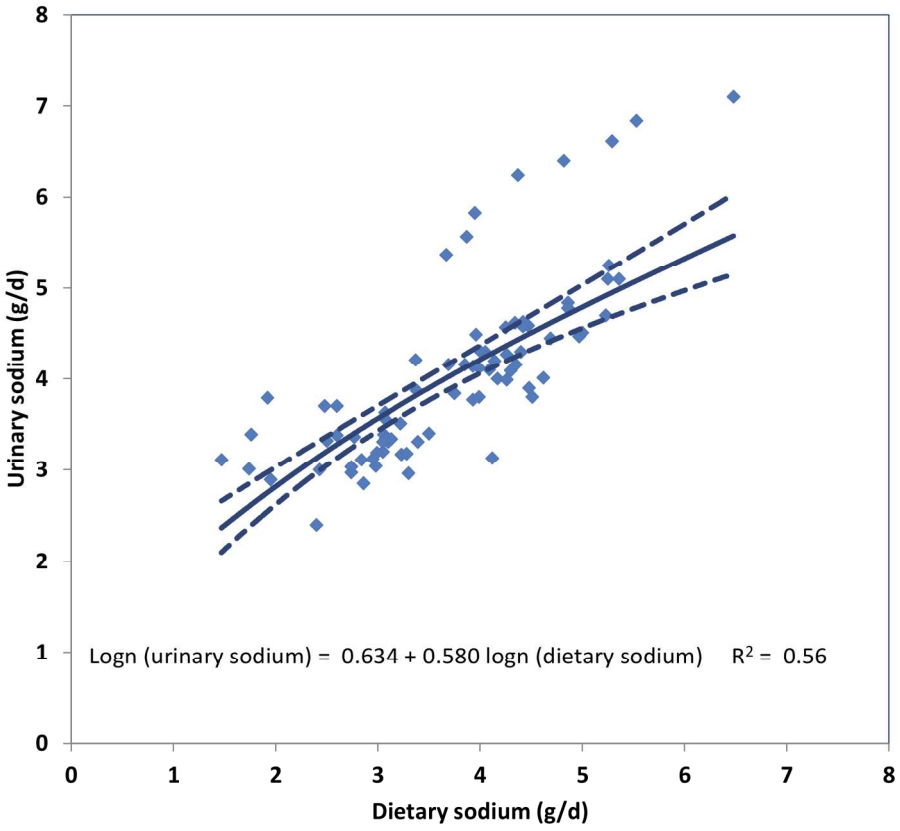

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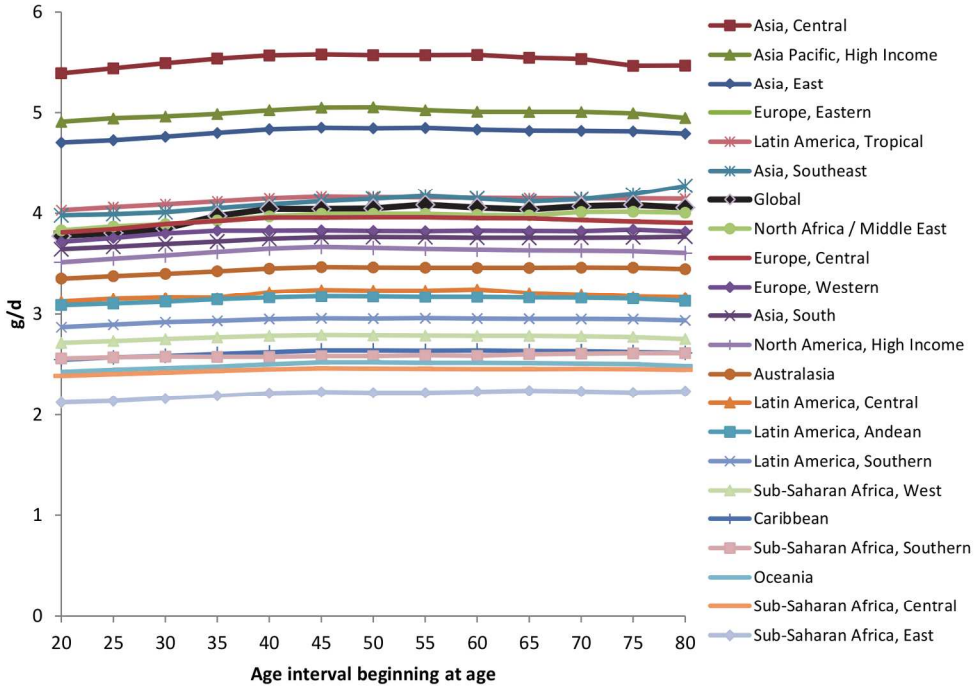

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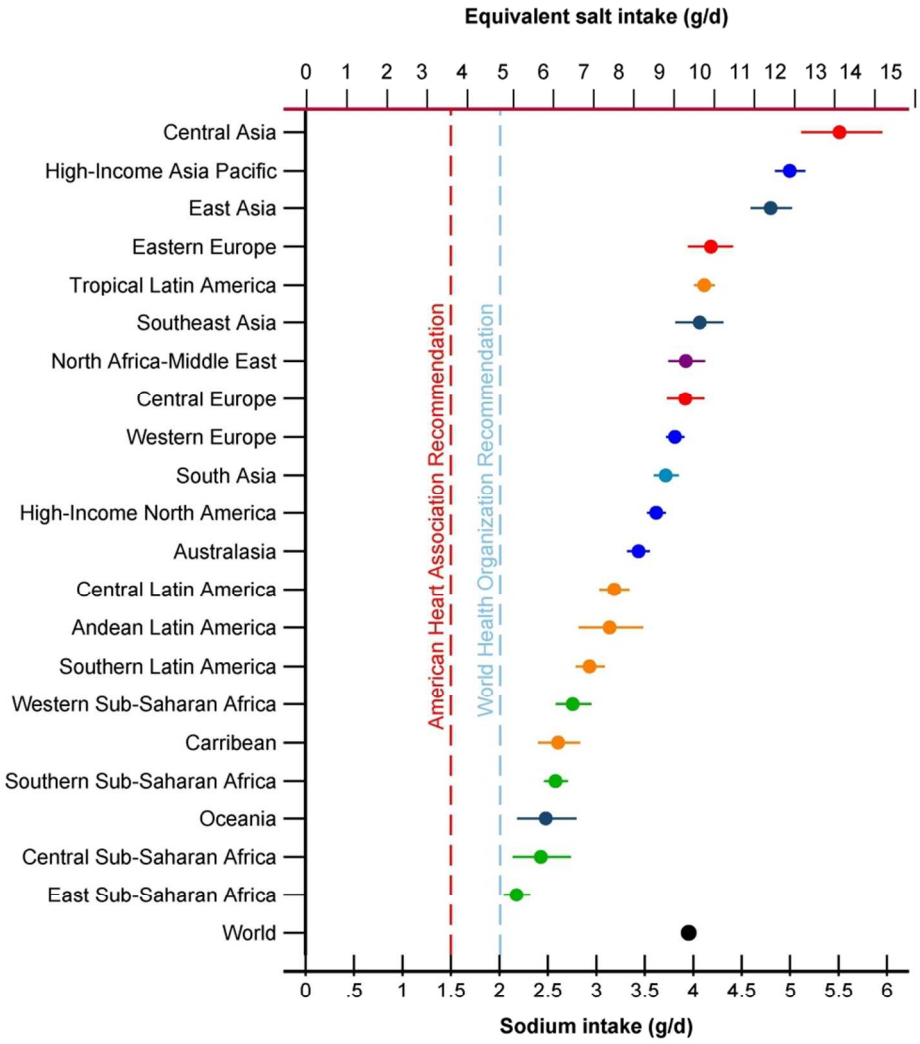

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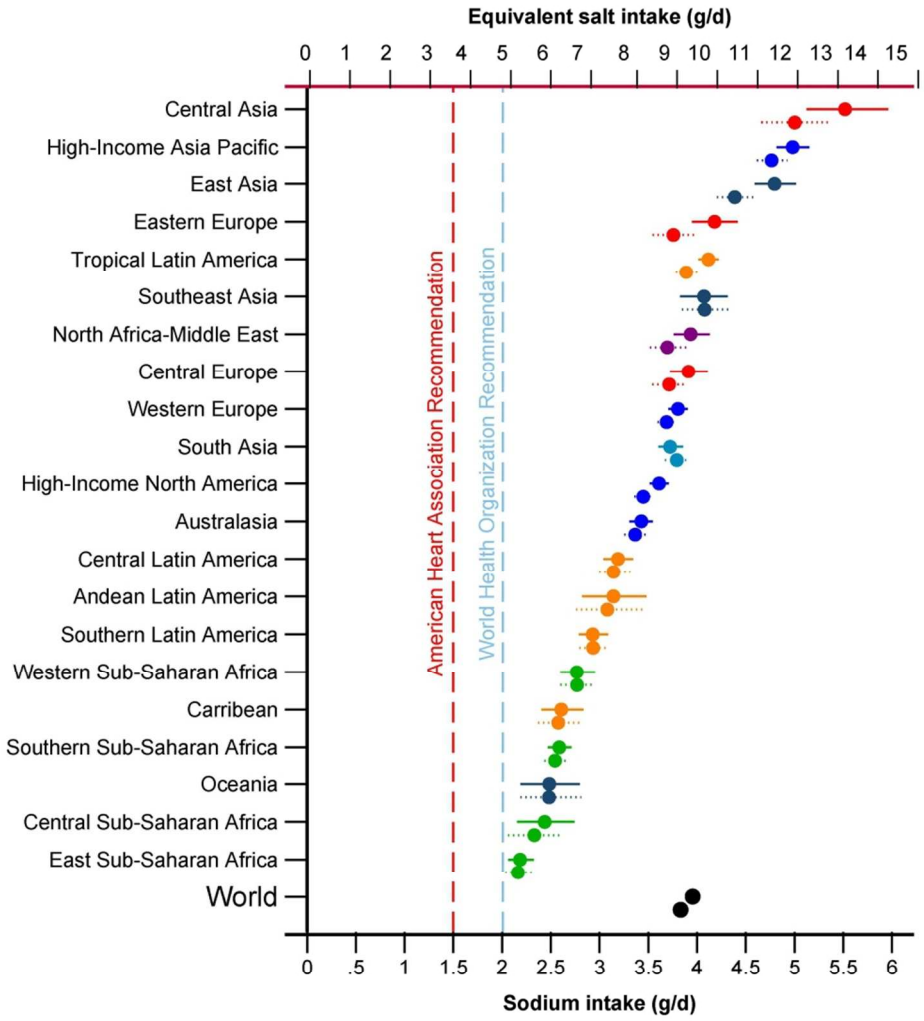

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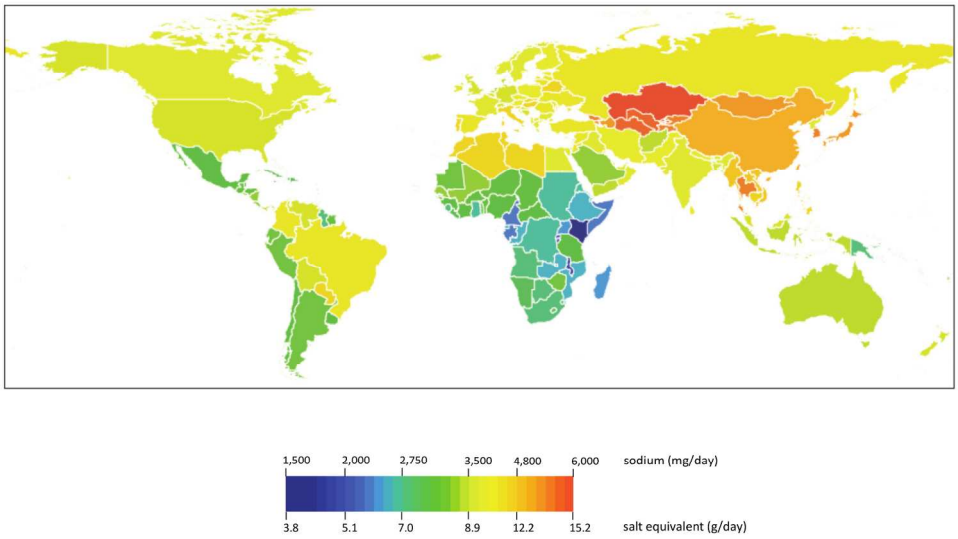

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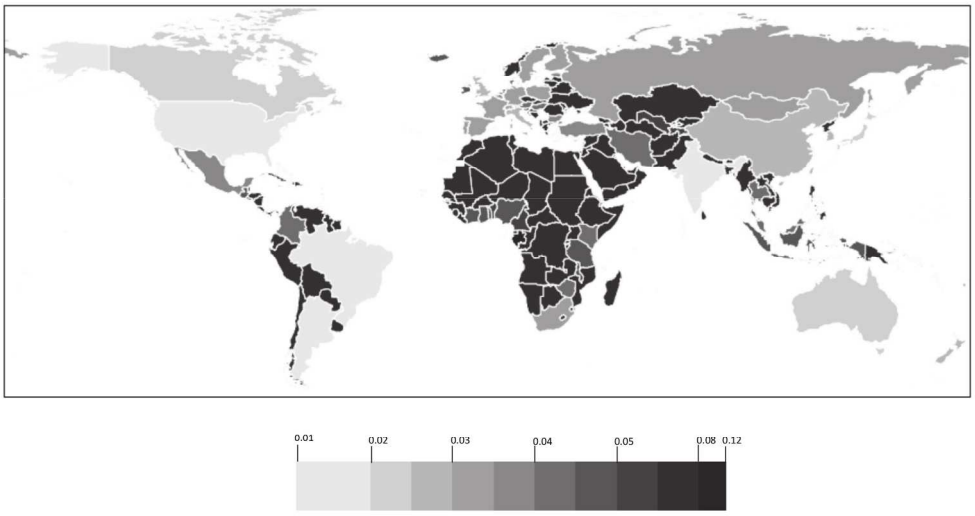

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Supplementary Table. Surveys and survey pairs used in the assessment of sodium exposure with identification of sources for published reports and of corresponding members where data was provided on request. Survey pairs, indicated by B (for Both) under Metrics, include both urine-based and diet-based surveys for the same source population.

Country (with included surveys)	Survey name or report authors (CM, corresponding members – see main text)	Metrics (Urine, Diet, Both)	Mid-year of data collect-ion	Nation-al, Subnat-ional	Sample size			Age range	Urine method (where applic.) [1]	Diet method (where applic.) [2]
					M	F	T [3]			
Asia-Pacific, High Income										
Japan	INTERSALT, Osaka [1]	U	1986	S	100	97		20-59	2	
Japan	INTERSALT, Tochigi [1]	U	1986	S	95	98		20-59	2	
Japan	INTERSALT, Toyama [1]	U	1986	S	100	100		20-59	2	
Japan	Liu et al. [2]	U	1991	N	484	542		48-56	2	
Japan	Kawamura et al. [3]	U	1993	S	90	50		30-65	2	
Japan	National Nutrition Survey (in Japan) [4]	D	1995	N	4,976	5,790		20-100		3
Japan	Sasaki et al. [5]	B	1996	S	308	138		20-25	4	3
Japan	The Japan Public Health Center-based Prospective Study (JPHC Study) [6]	D	1996	S	45,593	52,175		45-74		2
Japan	INTERMAP, Aito Town [7]	B	1997	S	260	258		40-59	2	3
Japan	INTERMAP, Sapporo [7]	B	1997	S	298	296		40-59	2	3
Japan	INTERMAP, Toyama [7]	B	1997	S	298	300		40-59	2	3
Japan	INTERMAP, Wakayama [7]	B	1997	S	292	288		40-59	2	3
Japan	National Nutrition Survey (in Japan) [8]	D	1998	N	5,067	5,850		20-100		3
Japan	Kimira et al. [9]	B	1999	S			438	27-84	4	3
Japan	The Japan Public Health Center-based Prospective Study (JPHC Study) [10]	D	2001	S	43,073	49,229		50-79		2
Republic of Korea	Korea National Health and Nutrition Examination	D	2005	N	2,877	3,563		20-100		3

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Country (with included surveys)	Survey name or report authors (CM, corresponding members – see main text)	Metrics (Urine, Diet, Both)	Mid-year of data collection	National, Subnational	Sample size			Age range	Urine method (where applic.)[1]	Diet method (where applic.)[2]
					M	F	T[3]			
	Survey (KNHANES) III [11]									
Republic of Korea	INTERSALT, Pusan [1]	U	1986	S	100	98		20-59	2	
Asia, Central										
Mongolia	Yamada et al. [12]	U	1998	N	571	598		20-44	4	
Asia, East										
China	Zhao GS et al. (1 of 3) [13]	U	1983	S	92			40-59	4	
China	Zhao GS et al. (2 of 3) [13]	U	1983	S	82			40-59	4	
China	Zhao GS et al. (3 of 3) [13]	U	1983	S	83			40-59	4	
China	Zhou BF et al. (1 of 9) [14]	D	1983	S	342			35-59		1
China	Zhou BF et al. (2 of 9) [14]	D	1983	S	124			35-59		1
China	Zhou BF et al. (3 of 9) [14]	D	1983	S	51			35-59		1
China	Zhou BF et al. (4 of 9) [14]	D	1983	S	119			35-59		1
China	Zhou BF et al. (5 of 9) [14]	D	1983	S	181			35-59		1
China	Zhou BF et al. (6 of 9) [14]	D	1983	S	215			35-59		1
China	Zhou BF et al. (7 of 9) [14]	D	1983	S	85			35-59		1
China	Zhou BF et al. (8 of 9) [14]	D	1983	S	212			35-59		1
China	Zhou BF et al. (9 of 9) [14]	D	1983	S	195			35-59		1
China	INTERSALT, Beijing [1]	U	1986	S	100	100		20-59	2	
China	INTERSALT, Nanning [1]	U	1986	S	100	100		20-59	2	
China	INTERSALT, Tianjin [1]	U	1986	S	100	100		20-59	2	
China	Liu et al. [2]	U	1992	N	403	408		48-56	2	
China	Nan et al. [15]	D	1992	N	1133	1184		20-64		1
China	INTERMAP, Beijing [7]	B	1997	S	266	278		40-59	2	3
China	INTERMAP, Guangxi [7]	B	1997	S	280	276		40-59	2	3

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Country (with included surveys)	Survey name or report authors (CM, corresponding members – see main text)	Metrics (Urine, Diet, Both)	Mid-year of data collect-ion	Nation-al, Subnat-ional	Sample size			Age range	Urine method (where applic.) [1]	Diet method (where applic.) [2]
					M	F	T [3]			
China	INTERMAP, Shanxi [7]	B	1997	S	286	292		40-59	2	3
China	2002 China National Nutrition and Health Survey [16]	D	2002	N	24,020	27,109		20-101		1
Taiwan	INTERSALT, San Chilo Village [1]	U	1986	S	89	92		20-59	2	
Taiwan	2005-2008 Nutrition and Health Survey in Taiwan [17]	D	2006	N	1,446	1,462		20-100		3
Asia, South										
India	INTERSALT, New Delhi [1]	U	1986	S	100	99		20-59	2	
India	INTERSALT, Stok, Ladakh [1]	U	1986	S	100	100		20-59	2	
India	National Nutrition Monitoring Bureau (NNMB) Rural Surveys [18]	D	1996	S	3,863	4,160		20-100		3
India	National Nutrition Monitoring Bureau (NNMB) Rural Surveys [19]	D	2000	S	8,314	8,888		20-100		3
India	Radhika et al. [20]	D	2003	S			1903	20-79		2
India	National Nutrition Monitoring Bureau (NNMB) Rural Surveys [21]	D	2005	S	8,824	9,468		20-100		3
Asia, South-East										
Indonesia	Mustafa et al. [22]	U	2003	S			15	25-55	4	
Malaysia	Malaysian Adult Nutrition Survey 2002 [23]	D	2002	N	3,117	3,340		20-59		3
Malaysia	Malaysian Adults Nutrition Survey 2003 [23]	D	2003	N	3,464	3,464		20-59		3
Thailand	Calcium Status, Factors Affecting Calcium and Bone Status in Healthy Thais Living in Bangkok [24]	D	1993	S	153	243		20-80		3
Thailand	Kwanmaung et al. (1 of 2) [25]	U	1998	S			14	20-79	4	
Australasia										
Australia	Beard et al. [26]	U	1989	S	22	32		24-69	4	
Australia	Notowidjojo et al. [27]	U	1992	S	64	64		20-64	4	
Australia	Beard et al. [28]	U	1995	S	87	107		20-70	2	
Australia	Margerison [29] (and CM)	U	2003	S	79	65		30-74	4	

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Country (with included surveys)	Survey name or report authors (CM, corresponding members – see main text)	Metrics (Urine, Diet, Both)	Mid-year of data collect-ion	Nation-al, Subnat-ional	Sample size			Age range	Urine method (where applic.) [1]	Diet method (where applic.) [2]
					M	F	T [3]			
Australia	Charlton et al. [30]	U	2007	S		78		20-56	4	
Australia	Land et al. [31] (and CM)	U	2011	S	144	162		20-88	4	
New Zealand	Simpson et al. [32]	U	1981	S	473	502		20-93	4	
New Zealand	Thomson and Colls [33]	U	1995	S	313	319		20-69	4	
New Zealand	NZ National Nutrition Survey 1997 [34]	D	1997	N	1,678	2,884		20-84		1
Caribbean										
Barbados	Cooper et al. [35]	U	1992	S			814	25-74	4	
Barbados	Identifying new genetic and obesity-related factors contributing to prostate and breast cancer risk in persons of African descent [36]	D	2005	N	152	128		31-88		2
Belize	Simmons et al. [37]	U	1980	S	392			20-94	4	
Jamaica	Cooper et al. [35]	U	1994	S			1,358	25-74	4	
Jamaica	Social and dietary determinants of body max index of adult Jamaicans [38]	D	1994	N	363	560		25-74		2
St. Lucia	Cooper et al. [35]	U	1992	S			1,088	25-74	4	
Trinidad and Tobago	INTERSALT, Plymoth-Bethesda [1]	U	1986	S	84	92		20-59	2	
Europe, Central										
Bulgaria	Powles et al. [39] (and CM)	U	1999	S	74	84		45-74	1	
Bulgaria	National Nutrition Survey [40]	D	2004	N	410	443		20-100		3
Hungary	INTERSALT, Porcsalam village [1]	U	1986	S	100	100		20-59	2	
Poland	INTERSALT, Warsaw [1]	U	1986	S	100	100		20-59	2	
Poland	Household Food Consumption and Anthropometric Survey [41]	D	2000	N	1,247	1,574		20-100		3
Slovenia	Ribic et al. [42]	U	2007	N	61	82		25-65	2	
Europe, East										

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Country (with included surveys)	Survey name or report authors (CM, corresponding members – see main text)	Metrics (Urine, Diet, Both)	Mid-year of data collect-ion	National, Subnat-ional	Sample size			Age range	Urine method (where applic.) [1]	Diet method (where applic.) [2]
					M	F	T [3]			
Estonia	Estonian National Dietary Survey [43]	D	1997	N	878	1,098		20-65		3
Russian Federation	INTERSALT, Moscow [1]	U	1986	S	97	97		20-59	2	
Europe, West										
Austria	Austrian Study on Nutritional Status 2007 [44]	D	2007	N	925	1,547		20-100		3
Belgium	Staessen et al. [45]	U	1980	S	273	255		20-88	4	
Belgium	INTERSALT, Charleroi [1]	U	1986	S	82	75		20-59	2	
Belgium	INTERSALT, Ghent [1]	U	1986	S	100	100		20-59	2	
Belgium	Zhang et al. [46]	B	1997	N	4,248	3,996		25-74	2	3
Belgium	Vandevijvere et al. [47]	U	2007	S	60	54		25-65	4	
Belgium	Vandevijvere et al. [47]	U	2009	S	66	69		25-65	4	
Denmark	INTERSALT, Glostrup [1]	U	1986	S	99	100		20-59	2	
Denmark	Dietary Habits of Denmark [48]	D	2001	N	1,448	1,486		20-100		1
Denmark	Andersen et al. [49]	U	2006	S	37	50		20-55	1	
Finland	Laatikainen et al. (2 of 11) [50]	U	1982	S	247	237		25-64	3	
Finland	Laatikainen et al. (6 of 11) [50]	U	1982	S	213	215		25-64	3	
Finland	Laatikainen et al. (8 of 11) [50]	U	1982	S	232	238		25-64	3	
Finland	INTERSALT, Turku [1]	U	1986	S	100	100		20-59	2	
Finland	Laatikainen et al. (3 of 11) [50]	U	1987	S	199	210		25-64	3	
Finland	Laatikainen et al. (7 of 11) [50]	U	1987	S	180	220		25-64	3	
Finland	Laatikainen et al. (9 of 11) [50]	U	1987	S	150	192		25-64	3	
Finland	FINDIET 1992 [51]	D	1992	N	870	991		25-64		1
Finland	Laatikainen et al. (11 of 11) [50]	U	2002	S	127	156		25-64	2	
Finland	Laatikainen et al. (4 of 11) [50]	U	2002	S	168	174		25-64	2	
Finland	Reinivuo et al. [52]	D	2002	S	168	174		25-64		1

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Country (with included surveys)	Survey name or report authors (CM, corresponding members – see main text)	Metrics (Urine, Diet, Both)	Mid-year of data collection	National, Subnational	Sample size			Age range	Urine method (where applic.)[1]	Diet method (where applic.)[2]
					M	F	T[3]			
Finland	Reinivuo et al. [52]	D	2002	S	128	156		25-64		1
Finland	Reinivuo et al. [52]	D	2002	S	127	156		25-64		1
Finland	FINDIET 2007 [53]	D	2007	N	959	1,080		25-74		1
France	Meneton et al. (1 of 2) [54]	D	1999	N	672	802		20-92		1
France	du Cailar et al. [55]	U	2001	S			850	20-70	4	
France	Etude nationale nutrition santé (ENNS); National Nutrition and Health survey [56]	D	2006	N	975	1,701		20-74		1
Germany	INTERSALT, Bernried [1]	U	1986	S	99	98		20-59	2	
Germany	INTERSALT, Cottbus [1]	U	1986	S	99	99		20-59	2	
Germany	INTERSALT, Heidelberg [1]	U	1986	S	97	99		20-59	2	
Germany	German Nutrition Survey 1998 [57]	D	1998	N	1,691	2,170		20-79		2
Germany	Nationale Verzehrs Studie II, Ergebnisbericht, Teil 2 [58]	D	2006	N	6381	7578		20-80		1
Iceland	INTERSALT, Reykajavik and district [1]	U	1986	S	100	100		20-59	2	
Iceland	Dietary Survey of the Icelanders [59]	D	1990	N	531	564		20-80		3
Iceland	The Diet of Icelanders, Dietary Survey of The Icelandic Nutrition Council 2002 [60]	D	2002	N	517	601		20-80		3
Iceland	Olafsdottir et al. [61]	B	2003	S		120		25-55	1	3
Ireland	Flynn et al. [62]	U	1987	S	46	48		20-60	4	
Israel	Mabat First Israeli National Health and Nutrition Survey [63]	D	2000	N	1,540	1,700		25-64		3
Israel	Mabat National Health and Nutrition Survey of the Elderly (Zahav) [64]	D	2005	N	833	949		65-100		3
Italy	INTERSALT, Bassiano [1]	U	1986	S	99	100		20-59	2	
Italy	INTERSALT, Gubbio [1]	U	1986	S	99	100		20-59	2	
Italy	INTERSALT, Mirano [1]	U	1986	S	100	100		20-59	2	

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					M	F	T[3]			
Italy	INTERSALT, Naples [1]	U	1986	S	100	100		20-59	2	
Italy	Pavan et al. (1 of 4) [65]	D	1994	S			376	22-89		2
Italy	INN-CA 1994-96 [66]	D	1995	N	701	888		20-100		1
Italy	Venezia et al. [67]	U	2003	S	940			25-75	4	
Malta	INTERSALT, Dingli village [1]	U	1986	S	100	100		20-59	2	
Netherlands	INTERSALT, Zutphen [1]	U	1986	S	100	99		20-59	2	
Netherlands	Ocke et al. (CM)	U	2006	S	120	171		20-74	4	
Portugal	INTERSALT, Cartaxo Village [1]	U	1986	S	99	99		20-59	2	
Portugal	Polonia et al. [68]	U	2000	S			420	20-84	2	
Portugal	EPITeen Project [69]	D	2003	N	1,163	1,811		20-100		3
Spain	INTERSALT, Manresa [1]	U	1986	S	100	100		20-59	2	
Spain	INTERSALT, Torrejon [1]	U	1986	S	100	100		20-59	2	
Spain	Schroder et al. [70]	D	1995	S			1,561	25-54		1
Spain	The Catalan Nutrition Survey (ENCAT 2002-2003) and Serra Majem and Ribas, 2007 and Serra-Majem L et al., 2007 and Serra Majem et al., 2006 [71]	D	2003	N	869	1,054		20-100		1
Spain	Ortega et al. [72]	U	2009	N	196	222		20-60	4	
Sweden	Dietary habits and nutrient intake in Sweden 1989 [73]	D	1989	N	743	770		20-74		3
Sweden	Dietary habits and nutrient intake in Sweden 1997-98 [74]	D	1997	N	565	608		20-79		3
Switzerland	Chappuis et al. [75]	U	2010	N	663	687		20-79	2	
United Kingdom	Bingham et al. [76]	U	1985	S	71	50		25-44	1	
United Kingdom	Dietary and Nutritional Survey of British Adults 1986 [77]	B	1986	N	1,597	1,620		20-64	1	3
United Kingdom	INTERSALT, Belfast [1]	U	1986	S	99	100		20-59	2	
United Kingdom	INTERSALT, Birmingham [1]	U	1986	S	100	100		20-59	2	

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					M	F	T [3]			
United Kingdom	INTERSALT, Bridgend, South-Wales [1]	U	1986	S	100	99		20-59	3	
United Kingdom	Fogarty et al. [78] (and CM)	U	1991	S	836	845		20-74	4	
United Kingdom	National Diet and Nutrition Survey: people aged 65 years and over [79]	D	1994	N	632	643		65-100		3
United Kingdom	Khaw et al.(1 of 2) [80]	D	1995	S	3,583	4,013		45-79		1
United Kingdom	Khaw et al.(2 of 2) [80]	U	1995	S	160	180		45-79	1	
United Kingdom	INTERMAP, West Bromwich [7]	B	1997	S	282	276		40-59	2	3
United Kingdom	INTERMAP,Belfast [7]	B	1997	S	250	194		40-59	2	3
United Kingdom	National Diet and Nutrition Survey: adults aged 19-64 years 2000 [81]	B	2000	N	1,306	1,578		20-64	1	3
United Kingdom	Low Income Diet and Health Survey, 2003-2005 [82]	D	2004	N	1,021	1,910		20-100		1
United Kingdom	National Centre for Social Research [83]	U	2007	N	181	248		25-64	1	
United Kingdom	National Centre for Social Research [84]	U	2008	N	341	439		20-64	1	
United Kingdom	Scotish centre for Social Research [85]	U	2009	S	324	232		20-64	1	
Latin America, Central										
Colombia	INTERSALT, Tuquerres [1]	U	1986	S	96	95		20-59	2	
Guatemala	Melse-Boonstra et al. (4 of 4) [86]	U	1996	S		7		25-55	4	
Mexico	INTERSALT, Chihuahua [1]	U	1986	S	91	81		20-59	2	
Mexico	National Health and Nutrition Survey 2006 (Mexico) [87]	D	2005	N	5,898	9,848		20-59		2
Latin America, Southern										
Argentina	INTERSALT, Buenos Aires [1]	U	1986	S	100	100		20-59	2	
Argentina	Encuesta Nacional de Nutrición y Salud - National Nutrition and Health Survey (ENNyS) [88]	D	2004	N		4,429		20-49		3
Latin America,										

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Country (with included surveys)	Survey name or report authors (CM, corresponding members – see main text)	Metrics (Urine, Diet, Both)	Mid-year of data collect-ion	Nation-al, Subnat-ional	Sample size			Age range	Urine method (where applic.) [1]	Diet method (where applic.) [2]
					M	F	T [3]			
Tropical										
Brazil	Sarno et al. [89]	D	2002	N			48000	20-79		4
Brazil	Household Health Survey (ISA-SP) [90]	D	2003	S	724	806	1530	20-100		3
North Africa, Middle East										
Bahrain	National Nutrition Survey [91]	D	2000	N	1,120	1,181		20-70		3
Iran	Azizi et al. (1 of 2) [92]	D	1998	S			348	20-79		2
Iran	Azizi et al. (2 of 2) [92]	D	1998	S			343	20-79		2
Iran	Rahmani et al. [93]	D	2000	S			644	20-79		2
Iran	Rafiei et al. [94]	U	2001	S	304	608		20-60	4	
Kuwait	National Nutrition Survey for the State of Kuwait [95]	D	2008	N	403	517		20-100		3
Lebanon	National survey: Behavioral risk factor survey [96]	D	2008	N	1,207	1,385		20-100		2
Turkey	Dietary intake of adult population living in Ankara [97]	D	2005	S	348	1,136		20-84		3
Turkey	Erdem et al. [98]	U	2007	N	373	443		20-94	4	
North America, High Income										
Canada	INTERSALT, Labrador [1]	U	1986	S	78	83		20-59	2	
Canada	INTERSALT, St. Johns [1]	U	1986	S	100	100		20-59	2	
Canada	Canadian Community Health and Nutrition Survey [99]	D	2004	N	8,768	10,960		20-101		1
Canada	Garriguet [100]	D	2004	N	2,724	2,724		20-79		3
Canada	Shi et al. [101]	D	2004	N	3690	5177		30-79		3
USA	Holbrook et al. [102]	B	1981	S	24	32		20-53	4	1
USA	INTERSALT, Chicago [1]	U	1986	S	97	99		20-59	2	
USA	INTERSALT, Goodman, Blacks [1]	U	1986	S	93	93		20-59	2	

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Country (with included surveys)	Survey name or report authors (CM, corresponding members – see main text)	Metrics (Urine, Diet, Both)	Mid-year of data collection	National, Subnational	Sample size			Age range	Urine method (where applic.)[1]	Diet method (where applic.)[2]
					M	F	T[3]			
USA	INTERSALT, Goodman, Whites [1]	U	1986	S	99	99		20-59	2	
USA	INTERSALT, Jackson, Blacks [1]	U	1986	S	84	100		20-59	2	
USA	INTERSALT, Jackson, Whites [1]	U	1986	S	100	99		20-59	2	
USA	INTERSALT, Molokai, Hawaii [1]	U	1986	S	94	93		20-59	2	
USA	Cooper et al. [35]	U	1992	S			708	20-75	4	
USA	Espeland et al. [103]	B	1993	S			656	60-79	4	3
USA	Taylor et al. (1 of 2) [104]	U	1996	S		330		40-75	4	
USA	INTERMAP, Chicago [7]	B	1997	S	312	318		40-59	2	3
USA	INTERMAP, City of Woodlawn, Baltimore, Maryland [7]	B	1997	S	292	268		40-59	2	3
USA	INTERMAP, Corpus Christi, Hispanic [7]	B	1997	S	270	280		40-59	2	3
USA	INTERMAP, Corpus Christi, Non-Hispanic [7]	B	1997	S	272	272		40-59	2	3
USA	INTERMAP, Honolulu [7]	B	1997	S	272	262		40-59	2	3
USA	INTERMAP, Jackson [7]	B	1997	S	264	268		40-59	2	3
USA	INTERMAP, Minneapolis [7]	B	1997	S	260	260		40-59	2	3
USA	INTERMAP, Pittsburgh [7]	B	1997	S	264	256		40-59	2	3
USA	NHANES 2003-2006 [105]	D	2004	N	9,118	9,912		20-85		1
USA	Taylor et al. (2 of 2) [104]	U	2005	S		146		40-75	4	
Oceania										
American Samoa	American Samoa 1990 24 hr recall diet estimates [106]	D	1990	N	235	268		25-54		3
Niue	Taylor et al. [107]	U	1980	N	19	15		20-79	4	
Samoa	Western Samoa 1990 24 hr recall diet estimates [108]	D	1991	N	230	276		25-54		3
Sub-Saharan Africa, East										
Kenya	INTERSALT, Rambugu and Ndori villages [1]	U	1986	S	90	86		20-59	2	

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Country (with included surveys)	Survey name or report authors (CM, corresponding members – see main text)	Metrics (Urine, Diet, Both)	Mid-year of data collect-ion	Nation-al, Subnat-ional	Sample size			Age range	Urine method (where applic.) [1]	Diet method (where applic.) [2]
					M	F	T [3]			
Malawi	Simmons et al. (1 of 2) [109]	U	1983	S			76	20-79	4	
Malawi	Simmons et al. (2 of 2) [109]	U	1983	S			124	20-79	4	
Uganda	Pavan et al. (3 of 4) [65]	D	1994	S			136	22-89		2
United Republic of Tanzania	Pavan et al. (2 of 4) [65]	D	1994	S			234	22-85		
Sub-Saharan Africa, Southern										
South Africa	Barlow et al. (1 of 2) [110]	U	1982	S	150			30-50	4	
South Africa	Barlow et al. (2 of 2) [110]	U	1982	S	64			30-50	4	
South Africa	Food and nutrient availability in South African Households [111]	D	1995	N	416	502		20-99		2
South Africa	Charlton et al. (1 of 3) [112]	B	2002	S			228	20-65	4	3
South Africa	Charlton et al. (2 of 3) [112]	B	2002	S			224	20-65	4	3
South Africa	Charlton et al. (3 of 3) [112]	B	2002	S			200	20-65	4	3
South Africa	Maseko et al. [113]	U	2003	S			291	21-72	3	
Zimbabwe	INTERSALT, Harare [1]	U	1986	S	100	95		20-59	2	
Sub-Saharan Africa, Western										
Benin	Melse-Boonstra et al. (2 of 4) [86]	U	1996	S		13		22-55	4	
Cameroon	Cooper et al. [35]	U	1992	S			2828	25-74	4	
Cote d'Ivoire	Hess et al. (1 of 2) [114]	U	1997	S			54	20-79	3	
Cote d'Ivoire	Hess et al. (2 of 2) [114]	U	1997	S			57	20-79	3	
Ghana	Kerry et al. (1 of 2) [115]	U	2001	S			484	40-75	2	
Ghana	Kerry et al. (2 of 2) [115]	U	2001	S			532	40-75	2	
Nigeria	Cooper et al. [35]	U	1992	S			2508	45-94	3	

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[1] Quality control for urine collections:

1. PABA validation;
2. Exclusions based on observed/expected creatinine ratio or total urinary creatine (including Intersalt and InterMap);
3. Other strict urine collection protocols without use of PABA or creatinine;
4. Other collection protocol or not reported.

[2] Diet methods:

1. Multiple (≥2) short-term (up to 1 week) diet recalls/ records (with or without) correction for within-person variation;
2. Food frequency questionnaires;
3. Single short-term diet records/ recalls;
4. Household availability/ budget survey.

[3] For surveys where sex-specific data was not available.

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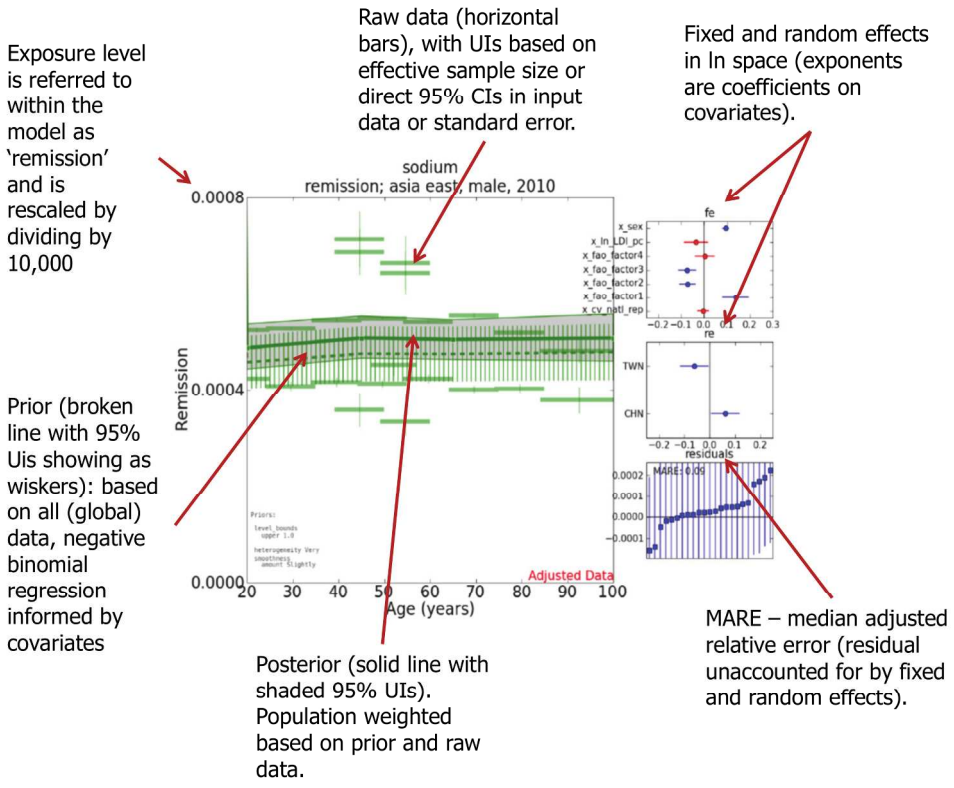

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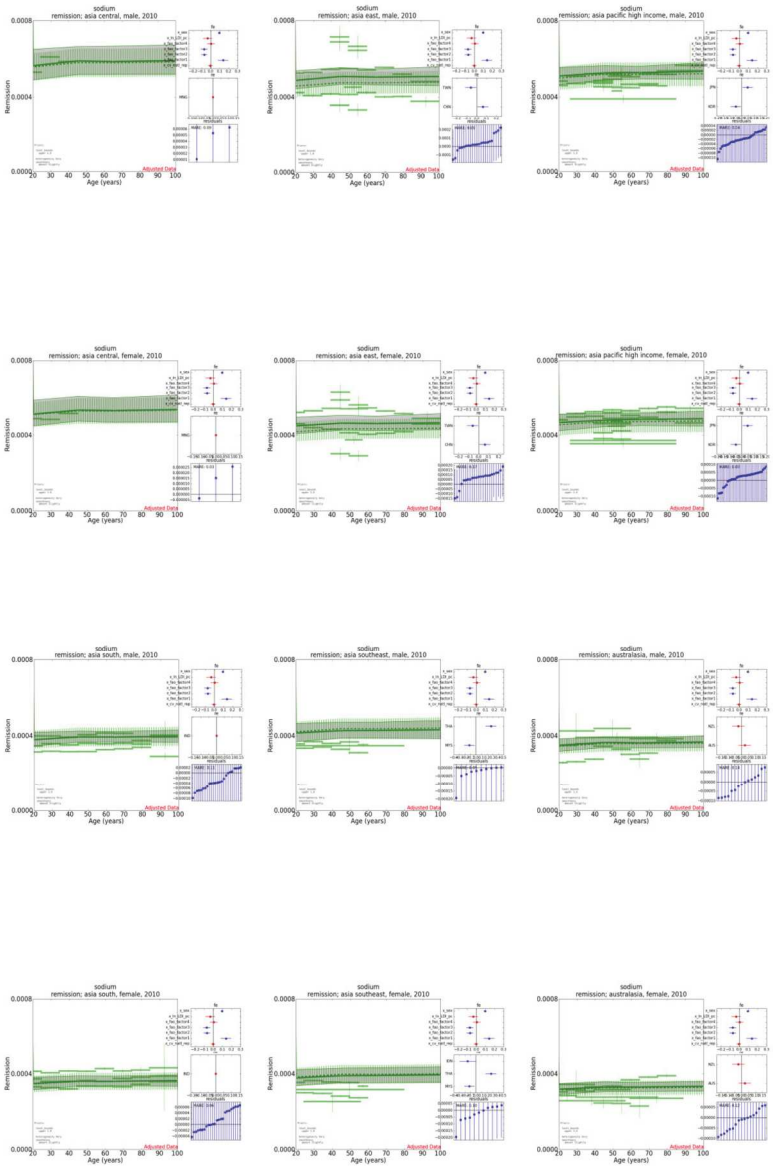

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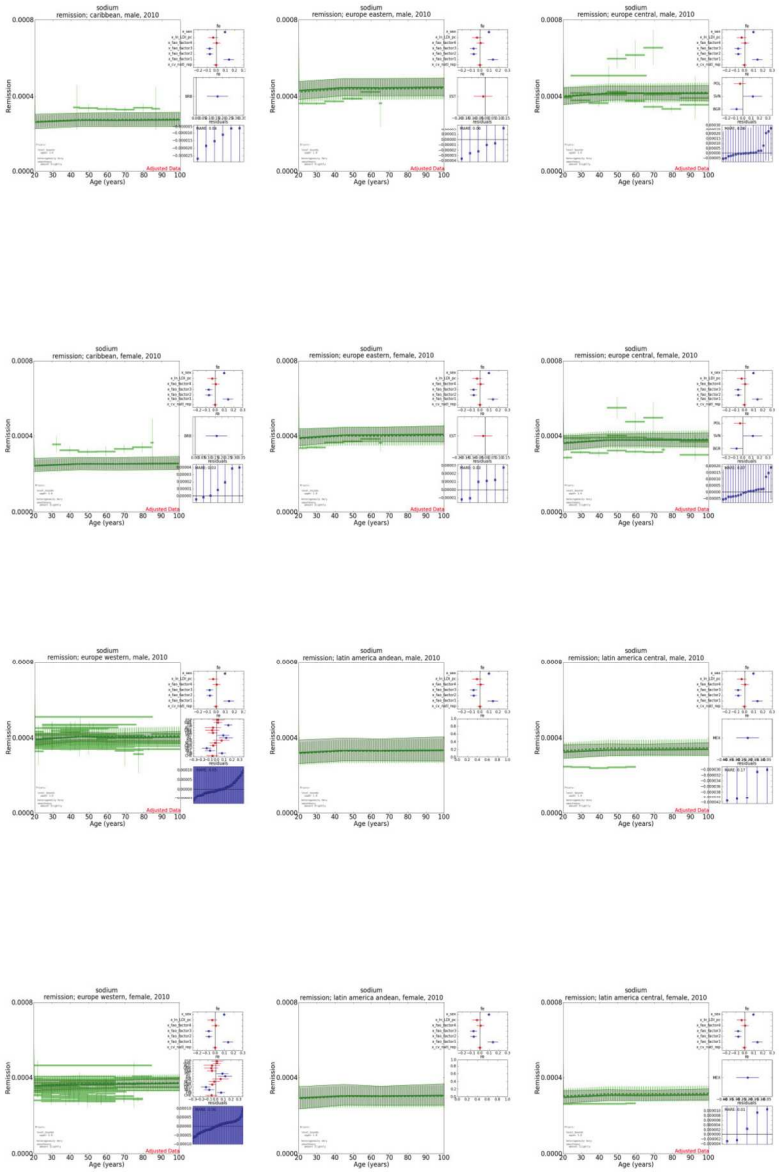

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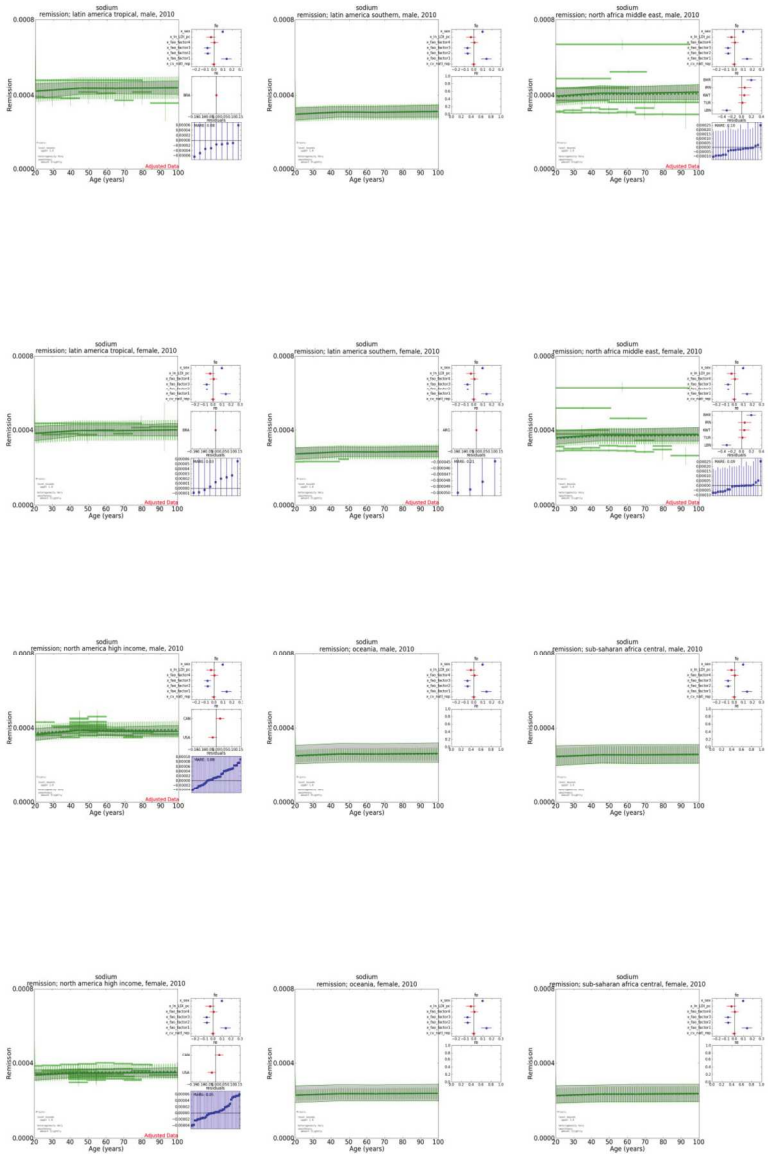

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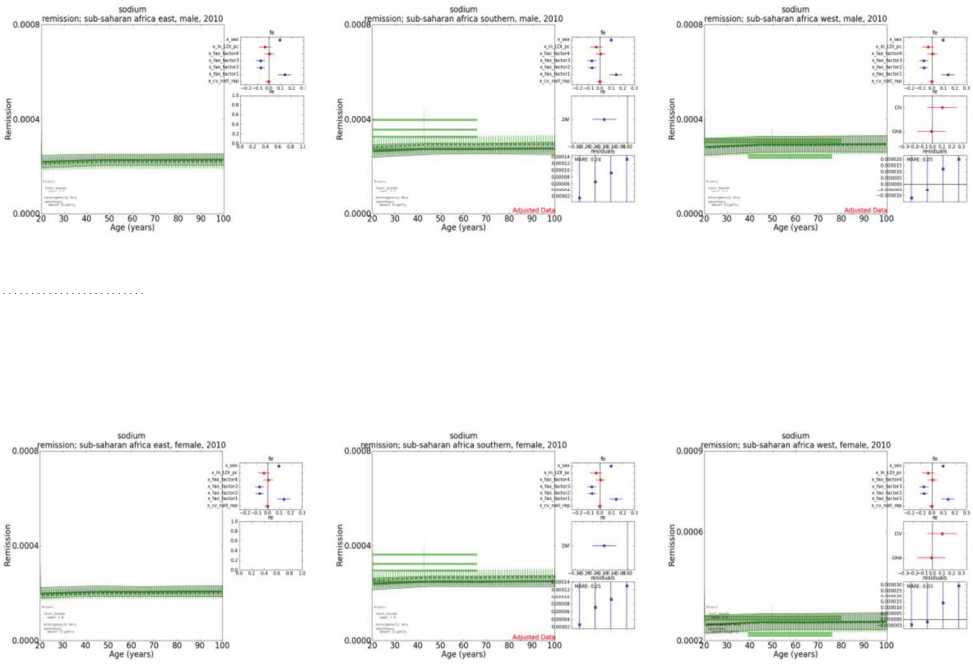

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METHODOLOGY SUPPLEMENT. THE IMPUTATION MODEL, DISMOD III

Modeling Strategy[i]

As sodium exposure data are available for only selected country-time periods, we estimated levels of sodium excretion for all country-time periods using an age-integrating Bayesian hierarchical model (DisMod III). The model includes fixed effects for study-specific and national-level covariates, and random effects by GBD super region, region, and country. Estimates for males and females in single year age groups, for 1990, 2005, and 2010 are produced.

We used both study-specific and national-level covariates in the model. We included one study-specific dummy variable to indicate whether the data are from non-nationally-representative studies/surveys. In addition, we allowed the variance of sub-national-level data to be different from nationally-representative data.

Time-varying country-level covariates were used in the model to inform the global and country-level trends and are not study-specific. We used data from the Food Balance Sheets of the Food and Agriculture Organization of the United Nations (FAO)[1] which captures a country's annual food availability for human consumption based on reported local production, imports and exports adjusted for other uses (livestock, seed). Taking into account that many of the food covariates are very collinear (for example, red meat, pig meat, and animal fats), and that consuming more of one food necessitates consuming less of other types, we used principal component analysis to generate four factor variables from the FAO data, based on the criteria that each factor must have an eigenvalue greater than one. Table S1 below shows the factor loadings on each of the 14 FAO variables, for the four factors (components). Although interpretation of these factor variables is not clear cut, red meats, animal fats, and pig meats have the highest loading in factor 1. Thus, factor 1 can be thought of as representing unhealthy meats. Seafood omega 3s, plant omega 6, whole grains, nuts, and vegetables have the highest loading in factor 2; fruits, legumes and nuts

[i] Text from the following source is used here with permission: Andrews K, Carnahan E, Ezzati M, Lim S, Murray C, and Sanman E. GBD 2010 Estimation Strategy Report for Attributable Burden to High Dietary Sodium Consumption, Unpublished report, Institute for Health Metrics and Evaluation, University of Washington, 2012.

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have the highest loading in factor 3. Factor 4 has the highest loading in sugars, stimulants, and saturated fats.

Lagged- distributed income (LDI) was also included as a country-level covariate. LDI per capita is GDP per capita smoothed with a 10-year weighted moving average.[2] We use LDI instead of straight GDP because it is more predictive of changes in health. Although GDP can experience drastic changes from year to year, changes in health and related outcomes are slower to change, meaning that the smoother measure of LDI more accurately predicts changes in health. The sources of GDP used are the Penn World Tables, The Maddison Project, the UN Statistics Agency, the World Bank, and the IMF (see[2] for detailed source information). The equation used to generate LDI:

LDI_y = (GDP per capita$_y$ + 0.9(GDP per capita$_{y-1}$) + 0.8(GDP per capita$_{y-2}$) + 0.7(GDP per capita$_{y-3}$) + 0.6(GDP per capita$_{y-4}$) + 0.5(GDP per capita$_{y-5}$) + 0.4(GDP per capita$_{y-6}$) + 0.3(GDP per capita$_{y-7}$) + 0.2(GDP per capita$_{y-8}$) + 0.1(GDP per capita$_{y-9}$))/5.5 (5.5 = the sum of the weights).

Table S2 presents the effect size estimated for the study-level and national covariates from the DisMod III model.

Table S1. Factor loadings used to create 4 FAO factor variables

Variable	Component 1	Component 2	Component 3	Component 4
Red meats	0.3614	0.1615	-0.1718	-0.1419
Animal fats	0.3546	0.1596	-0.1604	-0.1271
Fruits	0.1012	0.0712	0.6665	-0.1791
Omega- 6	0.3229	-0.296	0.0186	0.0288
Omega-3	0.0741	0.427	0.2574	0.3815
Whole grains	0.237	-0.3968	-0.1517	0.3163
Nuts	0.221	-0.2804	0.4033	0.1464
Vegetables	0.2777	-0.3197	0.1922	0.2252
Pulses/legumes	-0.2044	-0.146	0.4078	-0.4013
Alcohol	0.2896	0.0907	0.0103	-0.4957
Pig meat	0.3654	0.194	-0.1009	-0.2432
Saturated fats	0.0318	0.5036	0.171	0.3399
Stimulants	0.3031	0.1163	0.0559	-0.0203
Sugars	0.2992	0.0277	0.0493	0.1765

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Table S2. Effect sizes and standard errors for both study-level and national covariates.

Covariate	Mean Effect Size	Effect Size SE
Study-level covariate: non-nationally-representative data	0.995	0.013
Study-level covariate: male	0.135	0.011
National covariate: log LDI per capita	-0.100	0.051
National covariate: FAO factor 1	0.271	0.043
National covariate: FAO factor 2	-0.100	0.023
National covariate: FAO factor 3	-0.152	0.030
National covariate: FAO factor 4	-0.007	0.029

Standard deviations were estimated using a regression model using mean exposure, age and sex as the predictors.

Model output

Figure S1 gives an annotated output from the Dismod model.

Figures S2 to S5 show the model outputs for the regions.

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Figure Legends

Figure S1. Guide to model outputs for regions

Figure S2. Model output for regions (1)

Figure S3. Model output for regions (2)

Figure S4. Model output for regions (3)

Figure S5. Model output for regions (4)

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References

1 FAO FAOSTAT: Food Balance Sheets. FAO. Available: http://faostat3.fao.org/home/index.html#DOWNLOAD, accessed April 1, 2012.

2 James SL, Gubbins P, Murray CJ, Gakidou E Developing a comprehensive time series of GDP per capita for 210 countries from 1950 to 2015. Popul Health Metr 2012;10:12.