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National survey to estimate sodium and potassium intake and knowledge attitudes and behaviours towards salt consumption of adults in the Sultanate of Oman

Adhra Al-Mawali,[1,2] Lanfranco D'Elia,[3,4] Sathish Kumar Jayapal,[1] Magdi Morsi,[1] Waleed Nasser Al-Shekaili,[1] Avinash D Pinto,[1] Hilal Al-Kharusi,[1] Zainab Al-Balushi,[1] John Idikula,[1] Ayaman Al-Harrasi,[1] Francesco P Cappuccio [3,5,6]

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For numbered affiliations see end of article.

Correspondence to
Professor Francesco P Cappuccio;
f.p.cappuccio@warwick.ac.uk

ABSTRACT

Objectives To estimate population sodium and potassium intakes and explore knowledge, attitudes and behaviour (KAB) towards the use of salt in adults in the Sultanate of Oman.

Design National cross-sectional population-based survey.

Setting Proportional random samples, representative of Omani adults (18 years or older), were obtained from all governorates of the Sultanate of Oman.

Participants Five hundred and sixty-nine (193 men, 376 women; 18 years or older) were included in the analysis (response rate 57%). Mean age was 39.4 years (SD 13.1). Participants attended a screening including demographic, anthropometric and physical measurements.

Primary and secondary outcome measures We assessed dietary sodium, potassium and creatinine by 24-hour urinary sodium (UNa), potassium (UK) and creatinine (UCr) excretions. We collected KAB by a questionnaire on an electronic tablet.

Results Mean UNa was 144.3 (78.8) mmol/day, equivalent to 9.0 g of salt/day and potassium excretion 52.6 (32.6) mmol/day, equivalent to 2.36 g/day, after adjusting for non-urinary losses. Men ate significantly more sodium and potassium than women. Only 22% of the sample had a salt intake below the WHO recommended target of 5 g/day and less than 10% met WHO targets for potassium excretion (>90 mmol/day). While 89.1% of those interviewed knew that consuming too much salt could cause serious health problems and only 6.9% felt they were using too much added salt, one in two participants used always or often salt, salty seasonings or salty sauces in cooking or when preparing food at home.

Conclusions In the Sultanate of Oman, salt consumption is higher and potassium consumption lower than recommended by WHO, both in men and in women. The present data provide, for the first time, evidence to support a national programme of population salt reduction to prevent the increasing burden of cardiovascular disease in the area.

Strengths and limitations of this study

- National survey of Omani men and women using 24-hour urine collections.
- Adoption of quality control process to minimise the use of incomplete urine collections.
- Overall response rate was 57%, comparable with other similar population surveys.
- Non-responders did not differ in their baseline characteristics from responders.
- We cannot rule out the risk of selection bias.

INTRODUCTION

Non-communicable diseases (NCDs) are the leading, yet preventable, causes of death worldwide.[1] The reduction of its burden is now a global health priority of the UN,[2] endorsed by the WHO Action Plan that has identified a set of cost-effective policy options ('best buys'), of which reduction in population salt consumption is one.[3]

In the Sultanate of Oman, NCDs are among the leading causes of death, accounting for 72% of all deaths.[4] Cardiovascular disease (CVD) represents an increasingly common cause of population morbidity and mortality, accounting for 36% of all deaths.[4] It represents a major public health challenge undermining socioeconomic development.[5]

High blood pressure (BP) and unhealthy diets are the leading risk factors for CVD in the world.[1] Raised BP is a determinant of the CVD risk in the Sultanate of Oman, where the prevalence of raised BP in people aged 18 years or older is 33%, higher in men (39%) than in women (27%).[5 6]

High salt (ie, sodium chloride, 1 g=17.1 mmol of sodium) consumption is an important determinant of high BP. A high salt intake is associated with raised BP that leads to increased risk of vascular diseases.[7–10] In addition, high salt intake is related to adverse health effects independent of its effects on BP.[11–13] A moderate reduction in salt consumption reduces BP[7 8] and it can improve the health outcomes and indirectly reduce the overall mortality through beneficial effect on the BP.[9 10]

The WHO recommends that adults should consume no more than 5 g of salt daily.[14] However, mean daily intakes of salt in most of the countries in the world exceed this recommendation.[15 16] While there is no definitive estimate of population dietary salt intake in the Sultanate of Oman, average consumption could be high, similar to some countries in the subregion.[17 18] In the Sultanate of Oman, it is a common habit to add salt and salty condiments to food at the table and while cooking. Also, the habit of eating out is increasing (especially in urban areas), which leads to an increased salt intake, since restaurants tend to use higher amounts of salt to render food tastier. Our study was designed to support the salt reduction strategy of the Eastern Mediterranean region (EMRO), including the Sultanate of Oman, in which monitoring population salt consumption is one of the three pillars.[19] Current national initiatives include establishment of a multisectoral national committee, legislation on salt reduction, development of salt content benchmarks, dietary guidelines.[18] The 'Health Vision 2050' for the Sultanate of Oman was also developed as a roadmap by analysing extensively the status of the Omani health system, the morbidity and mortality in the population, the challenges facing the health system, the expected future developments and changes in the population including macrosocial and macroeconomic changes in order to augment the performance of the health system.

In contrast to sodium, epidemiological and intervention studies suggest beneficial effects of dietary potassium on BP and cardiovascular health.[20–22] The Sultanate of Oman lacks data on actual potassium consumption. The WHO currently recommends that adults should consume not less than 90 mmol of potassium daily.[23] Hence, we need reliable data on sodium and potassium intake in the Sultanate of Oman.

The primary aim of the present study was to establish current baseline average consumption of sodium and potassium by 24-hour urine collection, in a national random sample of Omani men and women. The study also aimed to explore knowledge, attitudes and behaviour (KAB) towards dietary salt.

MATERIAL AND METHODS

Participants and recruitment

We nested the salt survey within the main Oman NCD survey of 6833 households (online supplemental material 1, text S1). We recruited only one member per household. We designed the salt survey to collect 24-hour urinary samples from a subgroup of at least 90 participants from each governorate (region). The survey included only Omani citizens. We included a total of 999 randomly selected Omani men and women. They were all aged 18 years or older. They comprised residents of all governorates of the Sultanate of Oman (table 1). The sample was representative of the national sample for its general characteristics (see online supplemental table 1).

Table 1 Geographical sampling from the Sultanate of Oman

Governorate	Valid 24-hour urine collections	%
Muscat	67	11.8
Dhofar	79	13.9
Al-Dakhlia	45	7.9
North Sharqiah	36	6.3
South Sharqiah	45	7.9
North Batina	81	14.2
South Batina	53	9.3
Al-Dhahirah	46	8.1
Al Buraymi	84	14.8
Musandam	9	1.6
Al-Wasta	24	4.2
Total	569	100.0

From the sampling frame and according to the EMRO-WHO Protocol,[24] we excluded the following groups: people unable to provide informed consent, those with known history of heart or kidney failure, stroke, liver disease, those who recently began therapy with diuretics (less than 2 weeks), pregnant women, any other conditions that would make 24-hour urine collection difficult. To detect approximately 1 g reduction in salt intake over time using 24-hour urinary sodium excretion (difference ~20 mmol/24 hours), with an SD of 75 mmol/day (alpha=0.05, power=0.80), a minimum sample of 120 individuals per stratum is recommended.[24] Thus, we estimated a minimum recommended sample size of 240 per age and sex groups and adjusted for an anticipated non-response rate of 50%.[24] We stratified the population in groups by sex (men and women). Therefore, 480 individuals were originally needed to be selected (total n=120×2 groups/0.5 attrition=480).

The survey took place between December 2017 and May 2018. From the 999 individuals interviewed in the sampling frame, 569 of them (57.0%) provided suitable data for inclusion in the survey analysis. The general characteristics of the included participants did not differ substantially from those of the excluded participants (see online supplemental table 2). Originally, 262 (26.0%) did not provide complete urine collections (either declaring missing more than one void or providing collections <23 hour or above 25 hours), 87 (8.7%) had missing data, 48 (4.8%) provided urine collections with volume less than 500 mL (conventionally taken as not plausible) and 24 (2.4%) had urinary creatinine excretion outside two

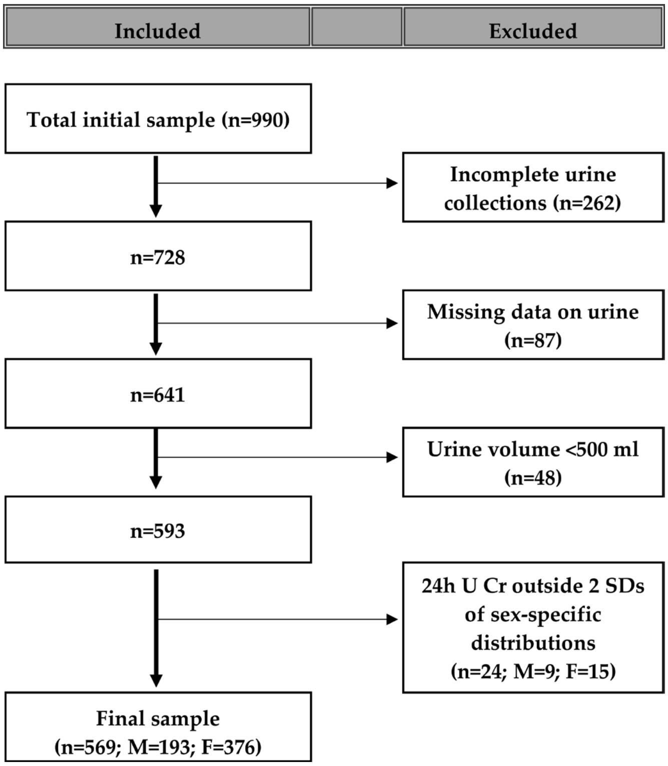

Figure 1 Stepwise procedure for the selection of valid participants according to protocol adherence, quality control and completeness of 24-hour urine collections.

SDs of the sex-specific distribution of urinary creatinine in the sample (figure 1).

Ethical considerations

We carried out the survey in accordance with the Declaration of Helsinki and Good Clinical Practice.[25]

Patient and public involvement

No patient involved.

Data collection

We performed the examination in a quiet and comfortable room, with the participants who did not smoke, exercise, eat and consume caffeine before attending and had been instructed to present with a full bladder 30 min before measurements to reduce the risk of underestimating the urine collection. We carried out the survey in three steps: (a) questionnaire survey, (b) physical measurements and (c) 24-hour urine collections.

We based the questionnaire on the Core and Expanded version of the WHO STEPS Instrument for Chronic Disease Risk Factor Surveillance (V.3.0)[26] and country-specific requirements. It contained 11 core, 1 optional and 4 country-specific modules that included a total of 420 questions, to determine sociodemographic characteristics of participants, key behavioural risk factors (tobacco use, harmful alcohol consumption, diet with frequency of fruit and vegetable consumption, high dietary salt consumption, oil and fat use, physical inactivity), knowledge attitudes and behaviour on dietary salt, given lifestyle advises and additional health-related information not presented here. KABs towards the consumption of salt were assessed by asking participants about the frequency, quantity and type of salt used in the household as well as their cooking habits and their attitudes and perceptions towards dietary salt intake. Processed food was defined, per WHO STEPS protocol, as foods altered from their natural state, such as packaged salty snacks, canned salty food, cheese and processed meat along with country-specific pictorial show cards.

We measured anthropometric indices, BP and heart rate in all participants. Height was in centimetre and body weight in kilogram using a standardised and calibrated SECA813 digital floor scales and 213 portable stadiometers, respectively. Body mass index (BMI) was calculated as weight (kg) divided by height squared (m^2). Waist and hip circumferences were measured by a non-stretch SECA201 measuring tape to the nearest millimetre.[24] We took systolic and diastolic BP and heart rate measurements three times in the right arm on a sitting position, using an appropriate cuff and a validated digital device (OMRON M3). We ignored the first measurement and used the mean of second and third measurements for analysis. We took measurements after the participant had rested for 15 min and each with 3 min of rest between the measurements (maximum deviation of cuff pressure measurement ±3 mm Hg and of pulse rate display ±5%). Hypertension is defined as systolic and/or diastolic BP ≥140/90 mm Hg or regular antihypertensive treatment.[27] We obtained a single 24-hour urine collection from the participants. We gave each participant a leaflet with explanations along with the necessary equipment and a record sheet on which they noted the start and the finish times of their urine collection, any missed urine aliquots and any medication taken during the collection. We instructed the participants carefully on urine collection methodology.[24] In an effort to minimise bias, we also requested participants not to change their diet before or during the day of the urine collection. They discarded the first void on waking on the day of collection. Participants then filled the 24-hour urine container over the 24-hour period. On the following day, the field team members visited the household, measured total volume, mixed it thoroughly and obtained a urine sample, which was kept in a cool box for transport to the respective laboratory. On arrival at the laboratory, we either carried out sodium, potassium and creatinine determinations immediately or stored samples in the fridge until the determination (as soon as possible). Sodium and potassium concentration in the urine samples were determined using an ion-selective electrode with an Abott C8000 & Roche Cobas 6000 and expressed in mmol/L.[28] Creatinine concentration was determined through either the kinetic (Abbott C8000) or enzymatic (Roche Cobas 6000) method and expressed in mg/dL.[29] These determinations were carried out in one reference laboratory in each of the 11 governorates, except for two regions (Dhofar and Musandam) which had two receiving reference laboratories each. All laboratories underwent joint quality control.

Statistical analysis

We performed all statistical analyses using the SPSS software, V.20 (SPSS). We used t-test for unpaired samples to assess differences between group means and Pearson χ^2 test to test the association between categorical variables. To convert urinary output into dietary intake, we first converted the urinary excretion of sodium (UNa) or potassium (UK) values (mmoL/day) into mg/day (for sodium 1 mmol=23 mg of sodium, for potassium 1 mmol=39 mg). We then multiplied the sodium value by 2.542 to convert dietary sodium (Na) intake into salt (NaCl) intake. We finally multiplied sodium values by 1.05 (assuming that approximately 95% of sodium ingested is excreted).[30] We calculated potassium dietary intake assuming that 85% of the potassium ingested is excreted in the urine.[31] The results were reported as mean (SD), median (IQ range) or as percentages, as appropriate. We considered two-sided p below 0.05 as statistically significant.

RESULTS

The final population sample included 569 participants between 18 and 69 years old (n=193 or 34% men and n=376 or 66% women), recruited nationally.

Characteristics of the participants

Table 2 shows the characteristics of the participants. There was no statistically significant difference in the mean age and in BMI between men and women, however, men had significantly higher BP and slower heart rate than women had. The prevalence of hypertension was on average of 27.4%, significantly higher in men than in women (38.5% vs 21.7%, p<0.001).

Daily urinary excretions of volume, sodium, potassium and creatinine and salt and potassium intake

Average urinary volume excretion was 1354 mL/day, being higher in men than women (table 3). Average urinary creatinine excretion was 1.33 g/day, being again higher in men than women (table 3). Mean urinary sodium was 144.3 (SD 78.8) mmol/24 hours, equivalent to a mean consumption of 9.0 (4.9) g of salt per day (table 3). Men excreted more sodium than women did (mean difference 15.0 mmol/24 hours, p<0.05), equivalent to ~1.0 g of higher salt consumption than women did. Only 22% of the participants met the levels of salt intake of 5 g or less recommended by the WHO, with no difference between sexes. Mean urinary potassium was 52.6 (32.6) mmol/24 hours, equivalent to a mean consumption of 2.36 (1.46) g of potassium per day (table 3).

Men excreted significantly more potassium than women; 9.1% of participants met the levels of potassium intake of 90 mmol/day or more recommended by the WHO.

The sex difference in total daily salt and potassium intakes is almost entirely due to the fact that men eat more food than women, as they are taller and heavier, despite having comparable BMI. This is a consistent finding across populations in different countries and from different continents.

KABs towards salt intake and other eating patterns.

KABs towards the consumption of salt are presented in table 4. A total of 28.1% of respondents mentioned that

Table 2 Characteristics of the participants

Variable	All (n=569)	Men (n=193)	Women (n=376)
Age (years)	39.4 (13.1)	38.7 (14.3)	39.8 (12.5)
Height (cm)†	159.4 (11.2)	167.9 (9.7)	154.9 (9.2)‡
Weight (kg)†	74.9 (21.5)	81.4 (22.5)	71.4 (20.1)‡
Body mass index (kg/m^2)†	29.3 (7.2)	28.9 (7.6)	29.5 (7.0)
Waist circumference (cm)†	93.8 (15.7)	95.0 (15.7)	93.2 (15.7)
Hip circumference (cm)†	104.5 (15.0)	102.6 (13.7)	105.5 (15.6)§
Systolic blood pressure (mm Hg)*	125.9 (18.2)	134.0 (17.0)	121.7 (17.3)‡
Diastolic blood pressure (mm Hg)*	80.9 (10.7)	83.4 (11.5)	79.7 (10.1)‡
Pulse rate (b/min)*	79.8 (10.5)	78.5 (11.8)	80.4 (9.8)§
Hypertension N (%)*	175 (30.8)	77 (39.9)	98 (26.1)‡
On antihypertensives N (%)*	50 (28.6)	15 (19.5)	35 (35.7)§

Results are mean (SD) or N(%).
Hypertension: Systolic Blood Pressure / Diastolic Blood Pressure >140/90 mm Hg or on current therapy for high blood pressure.
*3 missing values (1m, 2w) (0.5%).
†18 missing values (1m, 17w) (4%).
‡p<0.01.
§p<0.05 when compared with men.

Table 3 Daily urinary excretions of volume, sodium, potassium and creatinine, estimates of salt and potassium intake and proportion of participants meeting WHO recommended targets for salt and potassium consumption.

Variable	All (n=569)	Men (n=193)	Women (n=376)
Volume (mL/24 hours)	1354 (725)	1392 (712)	1335 (731)*
	1129 (855–1618)	1150 (900–1721)	1122 (827–1593)
Sodium (mmol/24 hours)	144.3 (78.8)	154.2 (87.4)	139.2 (73.6)*
	129.6 (85.7–187.4)	135.4 (87.1–204.8)	126.8 (83.9–179.4)
Potassium (mmol/24 hours)	52.6 (32.6)	56.4 (32.4)	50.6 (32.5)*
	46.4 (31.4–64.9)	50.9 (33.8–73.2)	44.7 (30.2–61.6)
Sodium-to-potassium ratio	3.3 (3.4)	3.5 (4.2)	3.2 (2.8)
	2.8 (2.0–3.8)	2.7 (1.9–3.9)	2.8 (2.1–3.8)
Creatinine (g/24 hours)	1.33 (0.71)	1.72 (0.87)	1.13 (0.52)‡
	1.18 (0.86–1.63)	1.61 (1.16–2.12)	1.02 (0.81–1.36)
Salt intake (g/day)	9.0 (4.9)	9.6 (5.5)	8.7 (4.6)*
	8.1 (5.3–11.7)	8.5 (5.4–12.8)	7.9 (5.2–11.2)
Potassium intake (g/day)	2.36 (1.46)	2.53 (1.45)	2.27 (1.46)*
	2.08 (1.41–2.91)	2.28 (1.52–3.28)	2.00 (1.35–2.76)
Salt <5 g/day N (%)	124 (21.8)	40 (20.7)	84 (22.3)
Potassium >90 mmol/day N (%)	52 (9.1)	24 (12.4)	28 (7.4)†

Results are mean (SD) and median (25th–75th percentile) or N (%).
*p<0.05.
†p=0.008.
‡p<0.001.

Table 4 Knowledge, attitudes and behaviours towards salt consumption

Question	All (n=569)	Men (n=193)	Women (n=376)
How often do you add salt or salty sauces to your food?			
Often/always	28.1%	22.8%	30.8%*
Sometimes	21.3%	17.1%	23.4%
Rarely/never	50.6%	60.1%	45.8%
How often is salt, salty seasoning or salty sauces added in cooking or preparing food at home?‡			
Often/always	47.0%	44.8%	48.1%†
Sometimes	16.5%	12.5%	18.6%
Rarely/never	36.5 %	42.7%	33.3%
How often do you eat processed food?‡			
Often/always	22.3%	22.8%	22.1%
Sometimes	38.3%	35.8%	39.5%
Rarely/never	39.4%	41.4%	38.4%
How much salt or salty sauces do you think you consume?‡			
Too much/far too much	6.9%	7.8%	6.4%
Just the right amount	66.8%	61.3%	69.7%
Too little/far too little	26.3%	30.9%	23.9%
Do you think that too much salt or salty sauces could cause a serious health problem?‡			
Yes	89.1%	90.1%	88.6%

*Results are percentages p=0.005.
†p=0.04 when compared with men.
‡Reduced numbers due to missing values.

Table 5 Frequency of other dietary patterns

Question	All (n=569)	Men (n=193)	Women (n=376)
In a typical week, on how many days do you eat fruit?§			
<5	32.0%	40.4%	27.7%†
≥5	68.0%	59.6%	72.3%
How many servings of fruit do you eat on one of those days?§			
<3	45.5%	41.8%	47.2%
≥3	54.5%	58.2%	52.8%
In a typical week, on how many days do you eat vegetables?§			
<5	24.1%	24.9%	23.7%
≥5	75.9%	75.1%	76.3%
How many servings of vegetables do you eat on one of those days?§			
<3	59.9%	65.9%	56.9%‡
≥3	40.1%	34.1%	43.1%
What type of oil or fat is most often used for meal preparation in your household?§			
Vegetable oil	90.8%	91.1%	90.7%
Other (lard, suet, butter, ghee)	9.0%	8.9%	9.0%
None used	0.2%	0	0.3%
On average, how many meals per week do you eat that were not prepared at home?§			
0	45.8%	32.1%	52.8%*
≥1	54.2%	67.9%	47.2%

*Results are percentages p<0.0001.
†p=0.002.
‡p=0.04 versus men.
§Reduced numbers due to missing values.

they added salt or salty sauces always or often to food. The percentage of women who added salt or salty sauces always or often to their meal was significantly higher than that of men (30.8% vs 22.8%; p=0.005). A total of 47.0% of respondents reported that they always or often added salt, salty seasonings or sauces when cooking or preparing food at home, women more than men (48.1% vs 44.8%; p=0.04). More than 1 in 5 (22.3%) mentioned that they consumed processed foods high in salt always or often. Very few (6.9%), however, felt they consumed too much salt or salty sauces, although 89.1% knew that consuming too much salt could cause serious health problems. We also asked participants about dietary attitudes about the consumption of fruit and vegetables, oil or fats (table 5). Interestingly, 68.0% consumed fruit at least 5 days a week and 54.5% at least three servings on these days. Men appeared to report more fruit consumption than women did (40.4% vs 27.7%; p=0.002). Vegetables were also consumed frequently (75.9% at least 5 days a week), with 40.1% having at least three servings on one of those days (women more frequently than men). The majority (90.8%) used vegetable oil for meal preparation in the household and more than half (54.2%) consumed food prepared outside home at least once a week. Men were more likely than women to do so (67.9% vs 47.2%; p<0.001).

DISCUSSION

This is the first nationally representative population-based survey carried out in the Sultanate of Oman assessing dietary sodium and potassium consumption in adult Omani men and women, using the gold standard measure of 24-hour urinary sodium and potassium excretions as a biomarker of intake. The results show that salt consumption is higher and potassium consumption is lower than recommended by the WHO,[14 23] both in men and women. Average population salt consumption was 9.0 g/day, almost double the WHO recommended maximum population target of 5 g/day.[14] Less than one in four participants met these targets. Salt consumption varied across governorates, being the lowest in South Sharqiah (5.3 g/day) and the highest in Al-Dhahirah (14.8 g/day). Average population excretion of potassium was 53 mmol/day (equivalent to about 2.36 g/day), lower than the WHO recommended maximum population target of >90 mmol/day, equivalent to approximately 3.90 g/day (assuming urinary potassium being 85% of the intake).[23] Potassium consumption also varied across governorates, being the lowest in Al-Wasta (1.41 g/day) and the highest in North Sharqiah (4.25 g/day). The urinary sodium-to-potassium ratio averaged 3.3, with no difference between men and women. Findings from the International Collaborative Study on Salt (INTERSALT) study showed that a difference in sodium-to-potassium ratio from 3.1 to 1.0 was associated with a 3.36 mm Hg difference in population systolic BP.[32 33] The Trial Of Hypertension Prevention (TOHP) study reported a direct association between the urinary sodium-to-potassium ratio and CVD.[10 34 35] Moreover, a unit difference in the ratio would be associated with a 13% reduction in total mortality.[35] Measuring the ratio is obviously important, although no evidence-based global guidelines have determined population targets, as yet.

Our questionnaire revealed that half of the population seen often used sauces and condiments (invariably containing high concentrations of salt) but only 10% believed this was too much. A quarter of the surveyed population added salt to food regularly, one in five ate processed food often and more than half of the population ate out at least once a week, with men more likely than women. These results, in addition to those obtained in previous surveys on unhealthy dietary habits, support the National Health Vision set by the Sultanate of Oman to reduce the burden of CVD.[36] This document sets the health visions for the country in 40 years. The comprehensive analyses of many factors affecting the population health and the healthcare system indicate that NCDs, in the context of increased life expectancy and population ageing, pose a significant threat to the health of the Omani people and it identifies the need to be able to respond to this challenge. Population salt reduction is one of the priorities.

Comparison with countries of the Gulf Co-operation Council and of the Arab Peninsula

In the Gulf Co-operation Council (GCC) countries, populations lead a sedentary lifestyle, both hypertension and obesity are common[17] and they are major contributors to NCDs.[37] The estimated total mortality in GCC countries attributable to NCDs varies from 65% to 78%, with the highest estimates in Bahrain and Saudi Arabia and the lowest in Oman and Qatar, respectively.[37] Salt intake is deemed high in most countries of the EMRO Region, although there are only a few studies that directly measured population levels, with inconsistent results due to methodological inadequacies.[17 18] The Global Burden of Disease (GBD) estimates of average salt consumption using a Bayesian model suggest that salt consumption in GCC countries may vary from 8.0 g/day in Saudi Arabia to 13.5 g/day in Bahrain.[38] Estimates of salt intake in neighbouring countries would also range between 7.8 g/day in Lebanon and 10.3 g/day in Jordan.[38] The present study is one of the few nationally representative surveys in GCC countries using the gold standard method of assessment of dietary salt intake. Its results suggest an intake close to that estimated by the GBD. In addition to the GBD, however, our study also provides, for the first time, direct measures of average population potassium consumption also targeted by WHO recommendations for cardiovascular prevention.[20 23]

Many countries of the EMRO Region of WHO are developing and/or implementing national initiatives to decrease population salt intake.[18] National initiatives include the establishment of national multisectoral committees, the engagement of the government through regulatory measures and legislation (Bahrain, Iran, Jordan, Oman, Qatar), the specification of the food categories prioritised for action such as bread (Kuwait, Qatar) and canned foods (Iran), the development of national benchmarks and targets (Bahrain, Iran, Oman), dietary guidelines (Afghanistan, Lebanon, Oman, Saudi Arabia), media awareness campaigns (Lebanon, United Arab Emirates), salt labelling, collaborative actions involving the food industry and/or restaurants and food caterers (Kuwait, Qatar, United Arab Emirates) and the monitoring and evaluation of sodium intakes and salt content of foods (Iran, Lebanon, Oman, Qatar).

Comparisons with studies in other countries

National salt and potassium consumption surveys have been carried out in almost all regions of the world, especially in response to the recommendations from the WHO that identified population salt reduction as one of the most cost-effective and feasible approaches to prevent NCDs.[2 3] Globally, there is a high variation in the readiness of countries to adopt and implement the different aspects of the overall strategy, with low-income and middle-income countries still lagging behind.[39 40] Nevertheless, where surveys have been carried out to establish the size of the problem, average levels of salt intake have been very high in countries of Eastern Europe (10.8 g/day in Moldova and 11.6 g/day in Montenegro with potassium about 30% lower than recommended and sodium-to-potassium ratios of 3.0 and 2.4, respectively),[41 42] Central Asia (17.2 and 18.8 g/day in two sites of Kazakhstan),[43] China (twofold North-South gradient from 15.6 to 8.4 g/day and potassium about 60% lower than recommended)[44] and Australasia (about 9.0 g/day weighted means in Australia and 11.7 g/day in the Fiji Islands),[45 46] indicating urgent need for population interventions. The same studies have invariably indicated lower than recommended potassium excretion and high sodium-to-potassium ratio. In this respect, the average intake of sodium in Oman seems reassuring, as the achievement of the set targets appears more feasible that in other countries where intake currently still exceeds 10 g/day. However, potassium consumption is nearly half of what is recommended,[23] resulting in a high sodium-to-potassium ratio.

Strengths and limitations

Our study has several strengths. First, it is a population-based survey across the whole country. Second, it included all adults. Third, it included both men and women. These study characteristics would allow with greater confidence the extrapolation of results to the whole country population, rather than those conducted in selected groups including patients,[47] young female university students[48] or children.[49] Fourth, it used the current preferred methodology for estimating salt consumption. Fifth, we applied a rigorous quality control protocol to ensure completeness of urine collections and to minimise both under and overestimations. Current recommendations suggest the use of single complete 24-hour urine samples, collected from a representative population sample to assess the population's current 24-hour dietary sodium ingestion.[50] The role of single-spot or short duration timed urine collections in assessing population average sodium intake requires more research. Single or multiple spot or short duration timed urine collections are, on the other hand, not recommended for assessing an individual's sodium intake especially in relationship to health outcomes.[50] Twenty-four-hour diet recall and diet records inaccurately measure dietary sodium intake in individuals compared with the gold standard 24-hour urinary excretion.[51] Furthermore, there is poor agreement between estimates of sodium intake from food-frequency questionnaires and 24-hour urine samples.[52] Sixth, it has measured directly the amount of potassium consumption, additional nutrient targeted for cardiovascular prevention.[20 23] Seventh, we standardised fieldwork and used standardised laboratory methodologies across the country. Eighth, all laboratories underwent joint quality control.[25]

There are limitations too. First, we included only 57% of the urine samples originally collected from willing individuals. This was due to the stringent quality control that has led to the exclusion of incomplete or erroneous collections.[24] This could have introduced a self-selection bias. The comparison of the baseline characteristics of the studies sample versus the excluded group suggests that the two groups were comparable for general characteristics, with the exception of the latter being 2 years younger and having a 1.8 mm Hg lower diastolic BP. Second, we assessed urinary sodium and potassium excretions only once. While we cannot characterise an individual's intake in such a way,[50] there is less likelihood of a bias of group estimates. Third, although we requested participants not to change their diet prior to urine collection, it would be difficult to rule out entirely any bias during collection. Fourth, although we administered a questionnaire to derive KABs towards the use of salt, we were unable to establish the relative contribution of discretionary sources of salt and the most common foods contributing to salt as well as potassium consumption.

Potential impact

The population in the Sultanate of Oman is of just over 5 million (Ministry of Health Annual Health Report, 2018 estimates), of which about 2.3 million are Omani nationals[4] (surveyed in the present study). Approximately 51% are 25 years or older. To meet a 30% reduction in population salt consumption set by WHO by 2025, the Sultanate of Oman should aim at a 2.7 g/day salt reduction nationally. This reduction would avert 8.1% CVD deaths per year and more non-fatal events and disabilities.[2] Additional benefits would be achieved if we increased at the same time population potassium intake towards WHO set targets, leading to a significant reduction in the sodium-to-potassium ratio in the diet. This could be achieved not only by increasing consumption of plant-based foods but also by enriching the diet with potassium-rich salt substitution in food manufacturing and processing or by using potassium-reach salts instead of sodium chloride, where sodium intake is predominantly originating from discretionary sources. Potassium-rich salts lower BP effectively[53] and the potential risk associated with potassium supplementation used at a population level[54] would be offset by a net reduction in CVD deaths.[55]

Policy implications

The Sultanate of Oman has embraced among its health priorities the prevention and control of NCDs and improvement in nutrition[4] in line with the strategic directions of WHO endorsed by the EMRO in 2012 and 2013[18]. Since then several countries have conducted dietary studies in an attempt to assess the population's salt and potassium intake.[18] Studies in the area have also attempted to identify the major dietary contributors to sodium intake. Studies are still limited and there are large variations in dietary habits in the region due to cultural, ethnic, religious and social heterogeneity. The most common source of salt consumption across the region is bread,[18 56] in all its different forms, with other sources being more relevant in different countries. In Lebanon[57] and Bahrain,[58] dairy products are common sources, while in Morocco,[59] major contributors to salt consumption include cereal-based products, spices and condiments and milk products. These indications, together with the awareness and behaviours measured, suggest that to reduce population salt consumption in the Sultanate of Oman, the following initiatives should be taken: (a) improving salt-related knowledge through health promotion campaigns, (b) measuring major sources of salt consumption, (c) establishing collaborations with local authorities to reduce the amount of salt used in traditional bread making and locally produced condiments, (d) adopting a labelling strategy for imported foods with high salt content. In addition, the Ministry of Health should develop strategies and methodologies to measure the indicators of population salt consumption.[60]

CONCLUSIONS

This study demonstrates that salt consumption in the Sultanate of Oman is high and should be reduced through a public health action aiming at the entire population. Likewise, potassium consumption is particularly low. The KABs survey indicates areas of limited awareness. Education of the dangers of high salt consumption and where salt is hidden, of the benefits of increasing potassium through fruit, vegetables, nuts and legumes, alongside accurate labelling and marketing of food, surveillance to measure and monitor salt use and reformulating bread are all important elements of an effective national salt reduction programme.[18 19 61]

Author affiliations
[1]Centre of Studies & Research, Ministry of Health, Muscat, Oman
[2]The Research Council, Seeb, Oman
[3]WHO Collaborating Centre for Nutrition, University of Warwick, Coventry, UK
[4]Department of Clinical Medicine and Surgery, "Federico II" University of Naples Medical School, Naples, Italy
[5]Division of Health Sciences, Warwick Medical School, University of Warwick, Coventry, UK
[6]Division of Medicine, University Hospitals Coventry & Warwickshire NHS Trust, Coventry, UK

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Contributors FPC developed the study design and protocol, contributed to the analysis and drafted the manuscript, AA-M trained local teams, coordinated quality control and data collection. MM and LD carried out quality control and statistical

analysis. AA-M, SKJ, WNA-S, ADP, HA-K, ZA-B, JI, AA-H coordinated the study, carried out the fieldwork and liaised with the local laboratory. MM helped with the drawing of the stratified random sample from the sampling frame. All authors contributed to the interpretation of the findings and they contributed significantly to the final version of the manuscript. FPC is the guarantor.

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Competing interests AA-M, SKJ, MM, WNA-S, ADP, HA-K, ZA-B, JI, AA-H are all staff of the Ministry of Health of the Sultanate of Oman. FPC is a technical advisor to the World Health Organization, unpaid member of Action on Salt and WASH. LD was a technical advisor to the World Health Organization and is a member of the Scientific Committee of the Italian Society of Human Nutrition.

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ORCID iD

Francesco P Cappuccio http://orcid.org/0000-0002-7842-5493

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SUPPLEMENTARY MATERIAL

TEXT S1. MATERIAL AND METHODS

1.1 Study Design

A national cross-sectional population-based survey was conducted using a representative sample of the Sultanate of Oman based on the WHO Stepwise approach to Surveillance (STEPS) of NCD risk factors (1), comprising the following aspects:

- **Step 1:** This consisted of face-to-face interviews using advanced standardized nation-specific version of the STEPS questionnaire and locally-adapted show cards to facilitate the understanding and operationalization of some questions. Socio-demographic characteristics, key behavioural risk factors, lifestyles, eye and ear health, history of chronic diseases and health care coverage were also elicited to better define exposure and health care seeking and control.
- **Step 2:** This involved physical measurements (e.g. weight, height, waist, hip circumference), and determination of blood pressure, heart rate, and vision function to investigate biological risk factors such as hypertension, overweight, obesity, and vision issues.
- **Step 3:** This aimed at determinations of biochemical markers levels (e.g. fasting capillary blood for glucose and lipid profile, and non-fasting urinary samples for sodium and creatinine) to identify hypercholesterolemia, hyperglycaemia, and sodium intake.

1.2 Sample Design

2.1 **Target Population:** The population of interest was all non-institutionalized persons, which included all men and women 18 years of age or older (Omani & non-Omani) who reside in the country.

2.2 **Inclusion population:** The target population includes all persons who consider the country to be their usual place of residence. This definition comprises those individuals residing in the country even though they may not be considered a citizen of the country.

2.3 **Exclusion population:** Those household members who were younger than 18 years of age; persons who have cognitive impairment that hampered understanding the questions to provide clear feedback; visitors (tourists) to the country; and, institutionalized people or those who indicated their usual place of residence was a military base, labour camps or group quarters, were excluded from the survey.

1.3 Sample Frame

For the 2010 National census, the whole of the Sultanate of Oman was divided into 15,077 census blocks. A census block was defined as a collection of units (residential units), which includes 60 units or less, and it could involve one or more enumeration areas. The census block is the smallest unit of field work for census data collectors. A total of 399,274 households[1] were identified in these blocks (260,120 Omani and 139,154 non-Omani). Households for Omanis and non-Omanis could not be differentiated unless physically visited as they lived closely together and there were no specific places (blocks) for non-Omani. The number of blocks and households in each governorate was provided in the table below according to the National Census 2010 and the map below shows the distribution of blocks over the Sultanate of Oman by governorates (National Centre for Statistics & Information (NCSI), Sultanate of Oman). The same census blocks were updated and used in this NCD Risk Factor Survey as shown in Table 1.

Table 1: Number of blocks and households by governorate based on 2010 National Census comprising the sampling frame for Oman NCD risk factors survey, 2017

Governorate	Number of blocks	Number of Omani households
Muscat	3514	62299
Dhofar	1768	17926
Ad Dakhiliyah	1712	34611
North Sharqiyah	1173	20044
South Sharqiyah	1097	22455
North Batinah	2248	47193
South Batinah	1335	29355
Al-Dhahirah	884	14386
Al-Buraimi	531	5939
Musandam	513	3216
Al-Wusta	302	2696
Total	**15077**	**260120**

1.3.1 Mapping and listing update

Two persons were appointed and trained to perform the mapping and listing operation for each governorate by using 2010 census maps from the National Centre for Statistics and Information. Personnel visited selected blocks to update maps that depicted all the households within the selected block and update the list of households within those blocks, including

[1] A “Household (HH)” was defined as “either a one-person household, defined as an arrangement in which one person makes provision for his or her own food or other essentials for living without combining with any other person to form part of multi-person household or a multi-person household, defined as a group of two or more persons both related and unrelated living together who make common provision for food or other essentials for living”.

additional information (e.g. house number - Name of household head – nationality – language – description if needed).

1.4 Sampling Design

A multi-stage stratified cluster sampling was designed to select 9053 eligible subjects. Stratification was made on two factors: governorate and nationality (Omani and Non-Omani). The sample was drawn from the 2010 census block area (clusters). An ***equal size sample (cluster)*** was systematically randomly selected from each governorate. Selected clusters (blocks) had to be updated before the households were selected for survey (see previous section).

1.4.1 Rationale for preferring equal sample selection rather than proportional to population size

1. To get the desired precision and estimates of overall results and figures at the governorate level.
2. Proportional allocation would have resulted in a very small sample in a small governorate e.g. Al-Wusta with low precision in the estimate.
3. Equal sampling allowed high precision in individual stratum.
4. The experience from previous surveys in Oman. The lowest response rate was in Muscat governorate and one third of population live in Muscat so if proportional selection was used this would have directly affected the overall response rate.

In the first stage, all governorates in the Sultanate of Oman (11 governorates) were selected.

In the second stage, we stratify blocks (PSU) based on geographical location, 550 clusters, from all over the Sultanate of Oman (50 from each governorate) using systematic random sampling (Secondary Sampling Units (SSU)).

In the third stage: [Tertiary Sampling Unit (TSU)], the following was considered:

i) The households in each cluster were listed within each governorate i.e. households from the first cluster, then households from the second cluster till households from the 50th cluster.

ii) The households in all clusters were aggregated into two lists by nationality (Omani and Non-Omani households) in each governorate

iii) 823 households were systematically and randomly selected from list of all households according to above in each governorate, from these two lists (Omani and Non-Omani household lists) according to the ratio of Omani and Non-Omani households in each governorate.

In the fourth stage: Ultimate sampling unit USU), One eligible individual from each household aged 18 years old or older was selected randomly by a program on the Android tablet.

1.4.2 Sample Size

A WHO STEPS standard formula was used in the calculation of the sample size based on the guidelines/recommendations of the STEPS survey.

$n= Z_2 * P (1-P)/d_2$

Where;

n= the required sample size

Z= the probability value associated with the confidence level

P= the prevalence rate of NCDs risk factors in the country

d= the desired margin of error (precision).

In turn:

Z= 1.96 (95% confidence interval as recommended)

P= 0.5 (the conservative value of prevalence rate)

e= 0.05 (as recommended in the guidelines)

Using these values, the initial calculation was: n= 384 households

Also taken into account for sample size calculations were: a value of design effect, as recommended in STEPS surveys, to be 1.5; and, an anticipated response rate of 70% was estimated. By adjusting the sample by these factors, the sample size per cluster (governorate) results in:

$$n = \frac{384 \ x \ 1.5}{0.7} = 823 \text{ households}$$

To get the desired precision and overall figures adequate for age-sex groups and for overall estimate on governorates level, the sample size was:

n= 823 x 11 = 9053 households, with one individual selected per household

The 9053 households were distributed equally by governorate (823), proportional to nationality, according to the ratio of Omani and non-Omani households in each governorate as in Table 2.

Table 2: Oman STEPS survey sample size distributed, by governorate and nationality, 2017

Governorate	Selected no. of blocks in each governorate	Omani	Non-Omani	Total Households

Al-Mawali A, *et al. BMJ Open* 2020; 10:e037012. doi: 10.1136/bmjopen-2020-037012

Muscat	50	318	505	**823**
Dhofar	50	495	328	**823**
Ad Dakhiliyah	50	763	60	**823**
North Sharqiyah	50	520	303	**823**
South Sharqiyah	50	667	156	**823**
North Batinah	50	677	146	**823**
South Batinah	50	699	124	**823**
Al-Dhahirah	50	586	237	**823**
Al-Buraimi	50	722	101	**823**
Musandam	50	713	110	**823**
Al-Wusta	50	663	160	**823**
Total	**550**	**6823**	**2230**	**9053**

1.5 Data collection instruments and procedures used in the survey

1.5.1 Selection of participants

Upon selection of a household, all potential individuals for interview were identified and their age and gender recorded in a household list, subsequently used to determine selection probabilities and response rate. To randomly select an eligible individual from a household, the Kish method was used using an electronic tablet and software. Once individuals were selected, they were informed about the survey aims and asked to provide their consent to participate in the interview and subsequent measurement procedures.

1.5.2 Questionnaire (STEP 1)

An advanced standardized[2] country-specific version of the questionnaire, based on the Core and Expanded version of the WHO STEPS Instrument for Chronic Disease Risk Factor Surveillance[3] and country-specific requirements, contained 11 Core, 1 Optional and 4 country-specific modules, to determine socio-demographic characteristics of participants, key behavioural risk factors (tobacco use, harmful alcohol consumption, diet with low fruits and vegetable intake, high salt intake, physical inactivity), given lifestyle advises, eye and ear health profile, history of chronic diseases, and health care coverage for diabetes, hypertension and dyslipidaemia, as well as cervical and breast screening.

In order to enhance the comparability with other countries in Arab region, the questionnaires from the Kuwait (2014), the Qatar (2012), the Bahrain (2007) and the Saudi Arabia (2005) STEPS surveys were taken into consideration. In addition, the questionnaire was translated from the original English version into Arabic as well as back translated, adapted to the local environment and needs, and piloted on 10 eligible respondents in terms of wording and

[2] validated
[3] Reference: The WHO STEPS Instrument for Chronic Disease Risk Factor Surveillance (1)

understanding. The data collection was conducted in two languages, namely: Arabic and English.

Table 3: Questionnaire content by STEPS survey and county-specific modules and questions in the Oman survey, by type, 2017

	STEP and county-specific modules content	Questions		
I	**Core modules (11)**	**Core**	**Expanded**	**Country-specific**
1	Demographic information	4	5	3
2	Tobacco use	11	7	
3	Alcohol consumption	12		
4	Diet, including dietary salt	8	3	2
5	Physical activity	15	1	
6	History or raised blood pressure	5		1
7	History of diabetes	6		1
8	History of raised total cholesterol	5		1
9	History of cardiovascular disease	3		
10	Lifestyle advise	1		
11	Cancers (cervical cancer screening)	1		3
	Subtotal 1	71	16	11
II	**Optional Module (1)**			
1	Tobacco policy	7		8
	Subtotal 2	7		8
III	**Country-specific Modules (4)**			
1	Family history of chronic disease			8
2	Asthma			11
3	Eye health			3
4	Ear health			4
	Subtotal 3			26
Grand Total: 139		**78**	**16**	**45**

1.5.2.1 Demographic information

All eligible household members aged 18 and above were listed with one eligible member selected randomly to answer the demographic information questionnaire. Demographic information was assessed in terms of age, sex, marital status, educational status, employment status, and family income.

1.5.2.2 Tobacco use

Tobacco use was assessed in terms of current smoking (past 30 days), whether daily or non-daily, and former smoking or never smoking status, age of initiation and duration of smoking, type and quantity of tobacco use daily or weekly, smokeless tobacco use type and frequency, and exposure to second-hand smoke at home or workplace. Smoking cessation attempts, having received health professionals' advice, age and time since stopping to smoke, recognizing tobacco advertisement, promotion or sponsorship, all while applying 33 questions[4] were also asked. To facilitate recognition of types of tobacco use, data collectors used show cards, depicting types of commonly used tobacco products. Likewise, the above metrics were determined for users of smokeless tobacco products.

1.5.2.3 Alcohol consumption

Alcohol consumption was assessed using the concept of a standard drink. A standard drink is any drink containing about 10 g of pure alcohol. Accordingly, determinations have been made from different types of alcoholic beverages consumed, as follows: e.g. 30 ml of spirits, 120 ml of wine or 285 ml of beer. Again, data collectors used show cards depicting types of containers commonly used to consume alcoholic beverages as standard drinks, to determine consumption over 30 and 7 days prior to interview. Also, in an attempt to quantify and estimate total alcohol consumption, interviewers considered not only the most frequent but all types of alcohol consumed (e.g. wine, beer and spirits) and the amount of drinks on such occasions. Also included in the questionnaire were aspects about stopping alcohol consumption for health reasons or impacts.

Respondents who reported consuming alcohol within the past 30 days were classified as current drinkers, while those who identified absence of alcoholic beverages within previous 12 months as abstainers or ex-drinkers. Three risk categories were used to classify respondents who consumed alcohol according to the average amount of alcohol consumed per occasion. Furthermore, heavy ("binge") drinking patterns were determined according to largest number of drinks per drinking occasion and the percentage of those having consumed six or more standard drinks on one occasion during the past 7 days.

1.5.2.4 Diet

To assess the dietary patterns of the surveyed population, the respondents were asked about frequency of fruit and vegetable consumption, mean number of portions of these foods consumed daily and weekly, type of oils and fat used for meal preparation, number of meals eaten outside the household per week and the amount of salt added, and/or salty sauces used or processed food or consumed daily, using 13 questions.

Sufficient consumption of fruit and vegetables was assessed in terms of the number of servings and also compared to WHO recommended number of ≥ 5 servings/day and ≥ 5 day/week, with

[4] Based on STEPS and GATS questionnaires (2)

a serving being equal to 80 g. Show cards were used to facilitate the collection data on fruit and vegetable consumption on a typical day. Oil and fat intake show cards were also shown to assess about the type of oil or fat most frequently used for preparing food or cooking.

In turn, salt consumption was assessed by asking about frequency of addition of salt or a salty sauce to food during preparation, or before or while eating; and/or frequency of consumption of processed food high in salt. Participants were also asked about their perception of the quantity of salt they consumed and its link with health problems, as well as about the importance of reducing salt intake, and the measures undertaken to control it. WHO recommends a reduction to <2 g/day sodium (5 g/day salt) in adults (3).[5]

Population mean number of daily portions and of days per week consuming fruits and/or vegetables were calculated. Also, the percentage distribution of respondents according to their servings consumed per day and those meeting the WHO recommendation of fruits and vegetables intake/day were determined.

Regarding salt intake, the proportions of people reporting how often they added salt to foods before eating or when preparing foods, as well as those who think they eat too much salt were determined. Percentage of participants were further determined according to their belief on the importance of salt in diet and whether they thought their consuming to much salt can cause serious problems.

1.5.2.5 Physical activity

Physical activity was assessed based on frequency, duration and intensity of physical activity at three segments: work (paid/ unpaid in and outside home), during transportation and on leisure time, for at least 10 minutes or more continuously per day, using a set of 16 questions[6]. Show cards were used to depict different types and places of physical activity.

According to WHO global recommendations on physical activity for (good) health, throughout a normal week adult should do at least the following amount of exercise (including activity for work, as well as during transport and leisure time): 150 minutes of moderate-intensity physical activity; or 75 minutes of vigorous-intensity physical activity; or an equivalent combination of moderate- and vigorous-intensity physical activity. Mean and median minutes of physical activity per day according to place were computed; as a complement, time spent on sedentary activities on average per day was also calculated. The proportion of respondents not meeting

[5] http://www.who.int/nutrition/publications/guidelines/sodium_intake_printversion.pdf
[6] Based on WHO Global Physical Activity Questionnaire (version 2) (4)

the WHO recommendations was also calculated. Likewise, the proportion of participants according to levels of physical activity as recommended by WHO were determined.

1.5.3 Physical measurements (STEP 2)

1.5.3.1 Blood pressure

Resting blood pressure levels, both systolic (SBP) and diastolic (DBP), were measured using Omron M3 digital blood pressure device as recommended by WHO. The measurements were repeated three times and the three readings were recorded. In order to obtain the measurements under relaxed conditions, persons were asked to void their bladder if needed, resting for 10-15 minutes after the interview, and not having drunk coffee before or during the measurement. In preparation for measurements, participants were asked to sit straight without crossing their legs. Blood pressure was measured placing a universal cuff on the left arm, which was placed with the palm face upward on a table surface at the level of the heart. While taking the readings participants were asked to remain silent. Repeat measurements were taken at 3-minute interval.

Participants were classified according to their blood pressure readings in the following categories: *normal* if their SBP and DBP readings were <140 mm Hg and <90 mmHg, respectively, and *high* if their SBP was ≥ 140 mm Hg and/or the DBP was ≥ 90 mm Hg, or if their readings were normal but they were under treatment for raised blood pressure in the past two weeks. In addition, *high risk* levels of SBP ≥ 160 mm Hg and/or DBP ≥ 100 mm Hg were also determined among participants to assess a higher probability or risk of hypertensive disorder.

Survey participants were also asked whether they were under medication for high blood pressure during the previous two weeks, as prescribed by a physician or other health professional. Respondents with treated and/or controlled raised blood pressure among those with raised blood pressure (SBP ≥140 and/or DBP ≥ 90 mmHg) or currently taking medication for raised blood pressure were further categorized to determine treatment success, treatment failure or being undetected and untreated, as follows:

- Under medication and controlled (treatment success) = those taking medication and having SBP <140 mmHg and DBP <90 mmHg;
- Under medication and uncontrolled (treatment failure) = those taking medication and having SBP ≥140 mmHg and/or DBP ≥90 mmHg;
- Undetected and uncontrolled (health system failure) = those not taking medication and having SBP ≥140 mmHg and/or DBP ≥90 mmHg**.**

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1.5.3.2 Body mass index (BMI)

The height and weight of participants was taken to estimate their body mass index (BMI) as the ratio of weight/height^2 (at the nearest decimal kilogram and decimal centimetre, respectively).

Measurements were carried out while standing with the heels together, feet apart, arms at sides and chin parallel to the floor on a flat, horizontal and firm surface (like tile, cement or wooden floor). Standardized and calibrated SECA® 813 digital floor scales and 213 portable stadiometers were used for weight and height measurements, respectively. To measure height and weight more precisely, participants were asked to follow standard procedures, including removal of their shoes and any bulky or heavy clothing to avoid overestimations.

Once BMI ratios determined, sample population was categorized according to the following WHO recommendations: underweight if BMI < 18.5, normal weight if BMI was between 18.5 - 24.9, overweight if BMI was between 25.0 - 29.9, and obesity if BMI was ≥ 30.

Average population BMI levels and proportion distribution among the sample population groups were determined.

1.5.3.3 Waist and hip circumferences

Waist circumference and hip circumference and their ratio were also assessed as other measures of obesity, in particular of central obesity.

Waist and hip circumference measurements were made while a participant remained standing, with feet together and hands on each side of the body, with a non-stretch Seca 201 measuring tape with millimetre precision. Waist circumference was measured by placing a tape measure around the bare abdomen at the midpoint between the lower margin of the last palpable rib and the top of iliac crest (hip bone). Hip circumference was measured by placing a tape measure around the maximum circumference over the buttocks.

The WHO cut-off points of waist circumference that determine waist obesity and categorized risk of metabolic complications and CVD are different for men and women. The waist–hip ratio (WHR) was computed among all respondents, excluding pregnant women.

1.6 Data collection

1.6.1 Staff recruitment

Interviewers and field supervisors in each governorate were recruited from among staff working in the Ministry of Health.

Overall, 66 data collectors and 11 field supervisors were recruited to participate in the training of data collection along with 1 regional coordinator, 1 IT technician and 1 laboratory technician in each governorate. Data collectors were mainly nurses and health educators nominated for data collection and for measurement of height, weight, waist and hip circumference, blood pressure, blood glucose, lipid profile, and vision testing. Urine samples were measured by the laboratory technicians in the health centre laboratories.

1.6.2 Data collection procedures

Field operations were carried out in the governorates during a four-month period in 2017, with the survey period chosen appropriately to avoid Ramadan/Eid periods. A media and advocacy action plan was implemented to raise awareness of the population about the survey, including disseminating information through leaflets, posters, press releases, radio and TV broadcasting, community and local Ministry of Health (MoH) staff participation. In addition to this focused publicity campaign, official identity cards to the field staff issued by MoH were of great help to secure sufficient recognition, cooperation and good responses for the interview in most cases. The respective authorities were also requested to provide the necessary assistance and co-operation to the field staff.

The interviews were conducted in all the governorates. The supervisors approached the selected households in each cluster, explained the aim and objectives of the survey, and sought their consent to participate in the survey. After recording the eligible members within a selected household, one participant was randomly selected from eligible members by the Android tablet. Each interview took place in a secure setting with adequate privacy at the household level. Each participant was interviewed at his/her household. As biomedical tests require 12 hours of fasting, appointments were given based on agreement between the interviewers and the respondents. Interviewers also explained the protocol for 24-hour urine collection to the respondent, obtained informed consent and provided the record sheet on which participants note the start and finish times of their 24-hour urine collection and any missed urine collections in the container.

1.6.3 Training for supervisors and data collectors

A one-week training program was conducted by the central research team from the Centre of Studies & Research in collaboration with WHO experts. This training program, which was held in Muscat in December 2016, included the survey objectives and field work staff duties, how to fill in the questionnaire in a polite, motivating and persuasive manner, how to understand the content of the questions if needed to clarify to respondents, how to enter the data and navigate the Android tablet, how to ask for written consent and organize data collection and protection of confidentiality of the informant (consent, ID barcode labels, patterns of verbal and nonverbal behaviour), how to perform physical measurements and take biomarkers' samples using equipment applying standardized methodology, and role playing and mock interviews.

The field supervisors were given special instructions afterwards on coordinating process. Trainees who failed to show interest in the survey and those who did not attend the training program on a regular basis were not selected for the fieldwork and were replaced by other staff from the same Governorate after training.

1.6.4 Pilot Study

The pilot testing of the survey implementation process was implemented for 2 days (using Android tablets) selecting about 100 households which included males and females as well as Omani and non-Omani households. The pilot was also used to train the key survey personnel, test all survey materials prior to full implementation (skip errors, translation errors, awkward wording, and inadequate response categories), check quality of data collected. Lessons learned, logistic issues, and challenges identified were considered which maximized opportunities for improving the quality in the full survey implementation.

1.7 Data Management

1.7.1 Data collection

Each participant was allocated an identifier code (PID). The PID code consisted of seven digits the first two digits were the device number; the next three digits were the house listing number in the cluster and the last two digits were the person number in the household.

Data from STEP 1 and STEP 2 were submitted electronically online to the server from a household with identification of individual PID, household geographical location, including cluster with individual PID, day and time of completion. This was done either daily or at least once a week. After being analysed, blood and urine samples' results (STEP 3) were uploaded to the server and merged into the unified dataset, following conversion into SPSS and Microsoft Excel format in a single file.

1.7.2 Data validation

The central team (at the Centre of Studies & Research) downloaded data daily from server for data cleaning and management over a period of 6 months. Data management included continuously monitoring data collection, uploading and consolidation processes in the field, validating quality of the data, creating weights, removing inconsistencies, namely "jump" errors/outliers, absence of data, excess data and invalid data. Moreover, to increase reliability of the collected data, verification of data in field was organized among 500 randomly selected households from all governorates. Accuracy of recording categorical and continued variables was checked using range and logic functions. The team also provided advice on software support and reported any problems or interview errors to the data collection field supervisors.

1.7.3 Data analysis

Weightage and Adjustment for sampling variation

Survey data analyses have to take into account whether the results are representative of the sample alone (unweighted analysis) or of the entire target population (weighted analysis). Since the primary objective was to be able to determine the estimates for the whole country, a weighted analysis was considered necessary. Weights adjusting for this complex survey design were required to decrease the risk of biases resulting from diverse factors. The sample weight is comprised of the inverse probability of selection. The household weights took into account the selection probability of the clusters within each stratum and the size (the number of households) of the cluster. The sample weight was also adjusted for non-response at the household level. The individual weight assumed that adults in the same cluster were selected by simple random sampling but the calculation scheme did not take into account the household size. This approach could have biased any key indicators, which was strongly associated with the household size. The individual weight was also adjusted for non-response.

Means, medians, proportions, standard errors, and 95% confidence intervals (95% CI) values were calculated to estimate central and dispersion measures and used to assess prevalence differences of NCD risk factors. Statistical procedures for data calculation and analyses were performed through two programs: EpiInfo in collaboration with WHO, and IBM SPSS (Version 20). All the figures and indicators in the tables were calculated using SPSS complex samples analysis. The figures presented as footnote (with an asterism) under each table were calculated after using population proportion weight. To allow for international comparisons of Oman survey results, age- and sex-adjusted overall values were calculated for all indicators using the direct method and the WHO standard population. Values are presented as footnotes on the tables to limit confusion with the national unadjusted data. It should also be noted that the estimates shown for governorates in the tables should be treated with caution as they represent the respondents in the respective governorate, and not the governorate itself.

1.8 Ethical considerations

Two informed consent forms, one for filling in the questionnaire and performing physical measurements (e.g. STEP 1 and STEP 2) and another for taking blood and urine samples for biomarkers (STEP 3), were requested to be signed by each participant. To enhance participation, an information letter was sent to all selected households in advance of data collection, identifying purpose, benefits and the voluntary participation in the survey.

To guarantee the high level of confidentiality and data security, every eligible subject was granted a unique identification number which was used for any reference from the register, with the exception of providing a personal feedback to a particular eligible subject for medical reasons.

Prior to its implementation, the survey was approved by the Research and Ethical Review & Approval Committee (RERAC) of the Ministry of Health.

Table S1. Comparison of the general characteristics of the study participants with those of the national sample of the 2017 WHO STEPS Survey carried out in Oman.

	Salt and Potassium Survey mean (SD)			**2017 WHO STEPS National Survey † mean (95% CI)**		
	All (n=569)	**Men (n=193)**	**Women (n=376)**	**All (n=6,582)**	**Men (n=3,365)**	**Women (n=3,217)**
Age (yrs)	39.4 (13.1)	38.7 (14.3)	39.8 (12.5)	38.2 (37.4-39.0)	38.0 (37.1-38.8)	38.6 (37.3-39.8)
Height (cm)	159.4 (11.2)	167.9 (9.7)	154.9 (9.2)	-	167.4 (166.6-168.2)	156.1 (155.5-156.6)
Weight (kg)	74.9 (21.5)	81.4 (22.5)	71.4 (20.1)	-	74.9 (73.6-76.2)	68.1 (66.6-69.7)
BMI (kg/m^2)	29.3 (7.2)	28.9 (7.6)	29.5 (7.0)	27.3 (26.9-27.6)	26.7 (26.3-27.2)	27.9 (27.3-28.5)
Waist circ. (cm)	93.8 (15.7)	95.0 (15.7)	93.2 (15.7)	-	90.0 (89.0-91.0)	87.6 (86.1-89.1)
Hip circ. (cm)	104.5 (15.0)	102.6 (13.7)	105.5 (15.6)	-	101.2 (98.8-103.5)	102.5 (99.2-105.7)
Systolic BP (mmHg)	125.9 (18.2)	134.0 (17.0)	121.7 (17.3)	124.9 (124.0-125.7)	130.3 (129.2-131.4)	119.1 (117.7-120.4)
Diastolic BP (mmHg)	80.9 (10.7)	83.4 (11.5)	79.7 (10.1)	79.5 (78.9-80.1)	81.5 (80.6-82.5)	77.4 (76.7-78.1)
Pulse rate (b/min)	79.8 (10.5)	78.5 (11.8)	80.4 (9.8)	79.4 (78.7-80.2)	77.7 (76.4-78.9)	81.3 (80.6-82.0)
Hypertension (%)	30.8	39.9	26.1	27.5	33.1	21.5

†https://www.who.int/ncds/surveillance/steps/Oman_STEPS_2017_Data_Book.pdf?ua=1

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Table S2. Characteristics of excluded participants and comparison with those included in the final analysis.

Variable	Included (n=569)	Excluded (n=159)	P value*
Age (years)	39.4 (13.1)	37.5 (13.9)	0.037
Height (cm)	159.4 (11.2)	158.7 (8.6)	>0.05
Weight (kg)	74.9 (21.5)	73.4 (18.3)	>0.05
BMI (kg/m^2)	29.3 (7.2)	29.1 (7.0)	>0.05
Waist circumference (cm)	93.8 (15.7)	92.3 (17.9)	>0.05
Hip circumference (cm)	104.5 (15.0)	102.6 (16.4)	>0.05
Systolic blood pressure (mm Hg)	125.9 (18.2)	124.2 (18.8)	>0.05
Diastolic blood pressure (mm Hg)	80.9 (10.7)	79.1 (11.6)	0.025
Pulse rate (b/min)	79.8 (10.5)	80.9 (10.5)	>0.05
Hypertension (%)	27.4	23.9	

Results are mean (SD), *by Mann-Whitney U-test

Hypertension: SBP/DBP >=140/90 mmHg

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