Sodium, Potassium and Iodine Intake, in a national adult population sample of the Republic of Moldova

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Abstract: In the Republic of Moldova, nearly 90% of all deaths are due to noncommunicable diseases (NCDs), the majority of which (58%) are caused by cardiovascular disease (CVD). Excess salt (sodium) and inadequate potassium intakes are associated with high CVD. Moreover, salt iodisation is the preferred policy to prevent iodine deficiency and associated disorders. However, there is no survey that has directly measured sodium, potassium and iodine consumption in adults in the Republic of Moldova. The aim is to estimate population sodium, potassium and iodine intakes and explore knowledge, attitudes and behaviour (KAB) towards the use of salt, amongst the adult population in the Republic of Moldova. Proportional random samples of adults were obtained from 28 of the 37 Districts and Municipalities and one Administrative Territorial Unit of Moldova. Participants attended a screening including demographic, anthropometric and physical measurements. Dietary sodium, potassium and iodine intakes were assessed by 24h urinary sodium (UNa), potassium (UK) and iodine (UI) excretions. Creatinine was measured. KAB was collected by questionnaire. Eight hundred and fifty-eight participants (326 men and 532 women, 18–69 years) were included in the analysis (response rate 66%). Mean age was 48.5 yrs (SD 13.8). Mean UNa was 172.7 (79.3) mmol/day, equivalent to 10.8 g of salt/day and potassium excretion 72.7 (31.5) mmol/day, equivalent to 3.26 g/day. Men ate more sodium and potassium than women. Only 11.3% of the sample had a salt intake below the World Health Organization (WHO) recommended target of 5 g/day and approximately 39% met WHO targets for potassium excretion (>90 mmol/day). Whilst 81.7% declared limiting their consumption of processed food and over 70% declared not adding salt at the table, only 8.8% looked at sodium content of food, 31% still added salt when cooking and less
than 1% took other measures to control salt consumption. Measures of awareness were significantly more common in urban compared to rural areas. Mean urinary iodine was 225 (SD: 152; median 196) mcg/24h, with no difference between sexes. According to WHO criteria, 41.0% had adequate iodine intake, 28.6% had intake below requirements and 17.8% and 12.6% had above requirement or excessive levels, respectively. Iodine content of salt table was 21.0 (SD: 18.6) mg/kg, with no difference between men and women. However, the content was lower in rural than urban areas (16.7 [SD: 18.6] vs 28.1 [SD: 16.5] mg/kg, p<0.001). There were weak or no correlations between urinary sodium and iodine excretions, and between urinary iodine excretion and iodine concentration in the table salt used in the participants’ households, indicating that in most cases participants were not using iodised salt as their main source of salt, more so in rural areas. In the Republic of Moldova, salt consumption is unequivocally high, potassium consumption is lower than recommended, both in men and in women, whilst iodine intake is still inadequate in 1 in 3 people, although severe iodine deficiency is rare. Salt consumed is often not iodised, with less iodised salt being used in rural areas.

**Keywords:** Republic of Moldova; salt; sodium; potassium; iodine; population.

1. **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 United Nations [2], endorsed by the World Health Organization (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 Republic of Moldova, NCDs are the leading causes of death, and cardiovascular disease (CVD) represents the main cause of population morbidity and mortality, accounting for every second death in 2016 [4]. This is a major public health challenge undermining socio-economic development.

High blood pressure (BP) or hypertension and unhealthy diets are the leading risk factors for CVD in the world and among the risk factors that account for most of the disease burden in the Republic of Moldova [5].

High salt (i.e., 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 [6-10]. 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 World Health Organization (WHO) currently 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 [15-17]. Since a high proportion of salt derives from hidden sources like processed food, food prepared in restaurants and other food outlets [18-19], objective assessment of actual salt consumption is necessary and currently lacking in the Republic of Moldova. Whilst there is no definitive estimate of population dietary salt intake in Republic of Moldova, it is believed that average consumption could be high, similar to some neighbouring countries in the sub-region, like Serbia (9.85 g/day) [20], Slovenia (11.3 g/day) ([21] and Montenegro (11.6 g/day) [22]. In the Republic of Moldova it is a common habit to add salt to food at the table and when cooking, as well as eating processed food that have high salt content. In 2013 a national survey indicated that 24.3% of those surveyed always or often added salt to food, and 32.4% always or often ate processed foods that are high in salt [5]. Salt reduction strategies in the European region, including the Republic of Moldova, encompass monitoring and evaluation actions as one of their important pillars [23]. Therefore, reliable data on salt intake in the Republic of Moldova are needed.

In contrast to sodium, epidemiological and intervention studies suggest beneficial effects of dietary potassium on BP and cardiovascular health [24-26]. The Republic of Moldova lacks data on actual potassium consumption. The WHO currently recommends that adults should consume not
less than 90 mmol of potassium daily [27]. Hence, reliable data on potassium intake in the Republic of Moldova are needed.

Finally, in the Republic of Moldova the prevention of iodine deficiency disorders recommends universal salt iodization [28]. Starting in 2009, the Ministry of Health authorised the production and placing on the market of iodized bottled water additionally to iodized salt. Since more than 90% of iodine consumed is excreted in the urine within 24-48 hours [29-30], 24h urinary iodine excretion is a good marker of recent iodine intake and is the ideal biomarker for assessing iodine status [31] in the entire adult population.

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

2. Materials and Methods

2.1 Participants and Recruitment

A total of 1,307 randomly selected men and women participated in the survey. They were all aged 18-69 years. They comprised residents of all Districts and Administrative Territorial Units ‘Gagauz-Yeri’, along with Chişinău and Bălţi Municipalities. The survey did not cover the Districts from the left bank of the Nistru River and the Municipality of Bender (Figure 1). A probabilistic master sample from the National Bureau of Statistics’ Household Budget Survey was used to select the sample for the survey which was extracted in three phases: 150 Primary Sampling Units (PSU - communes, cities or sectors within cities) were selected; list of households from PSU were drawn; eligible individuals from households were identified. Random sampling proportional to size were stratified by sex, geography (north, centre, south and Chişinău), urban/rural, size of cities.

Figure 1. Geographical sampling from the Republic of Moldova. National proportional random sampling from 28 (marked with a star) of 37 Districts and Administrative Territorial Units ‘Gagauz-Yeri’, along with Chişinău and Bălţi Municipalities. The sampling was as follows: Anenii Noi (1.3%), Balti (0.8%), Basarabeasca (1.4%), Briceni (4.7%), Cahul (3.5%), Călăraşi (2.4%), Cantemir (2.4%), Căuşeni (0.8%), Chişinău (30.7%), Comrat/ATU ‘Gagauz-Yeri’ (4.4%), Criuleni (4.3%), Edineţ (3.1%), Făleşti (2.4%), Floreşti (2.2%), Glodeni (1.2%), Hînceşti (0.7%), Ialoveni (4.4%), Nisporeni (3.0%), Ocniţa (2.7%), Orhei (4.8%), Rezina (1.7%), Rîşcani (0.6%), Singerei (1.9%), Şoldăneşti (2.6%), Soroca (2.2%), Ştefan Vodă (0.6%), Străşeni (2.7%), Ungheni (6.3%).
From the sampling frame and according to PAHO/WHO and EMRO-WHO Protocols [32-33], 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 two weeks), pregnant women, any other conditions that would make 24h urine collection difficult.

The survey took place between 21st July and 5th September 2016. From the 1,307 households and individuals interviewed in the sampling frame, 858 of them (66%) provided suitable data for inclusion in the survey analysis. Originally, 13 had missing data, 263 admitted missing more than one void, 77 provided either under-collections (<23h) or over-collections (>25h) and 37 had urinary creatinine excretion outside 2 standard deviations (SDs) of the sex-specific distribution of urinary creatinine in the sample (Figure 2).

![Diagram showing the stepwise procedure for the selection of valid participants according to protocol adherence, quality control and completeness of 24 hour urine collections.]

**Figure 2.** Stepwise procedure for the selection of valid participants according to protocol adherence, quality control and completeness of 24 hour urine collections.
The survey was carried out in accordance with the Declaration of Helsinki and Good Clinical Practice [34]. Ethical approval for the survey was obtained from the Committee of Research Ethics of the National Agency for Public Health of the Republic of Moldova and participants provided written informed consent to take part.

2.2 Data Collection

The examination was performed in a quiet and comfortable room, with the participants who were not allowed to smoke, exercise, eat, consume caffeine and to have a full bladder for 30 minutes before measurements. The survey was carried out in three steps: a) questionnaire survey, b) physical measurements and c) 24h urine collections.

The questionnaire (face-to-face interview, adapted version of the WHO STEPS Instrument for NCD Risk Factor Surveillance) [35] was used to collect data on respondent’s demographic and socio-economic status (by occupation and educational attainment); diet, frequency of high salt food consumption, fruit and vegetable consumption, knowledge attitudes and behaviour on dietary salt, history of high BP, diabetes and CVDs, lifestyle advice.

Anthropometric indices, BP and heart rate were measured in all participants. Height was measured in cm and body weight was measured in kg using a digital electronic device (body scale with height laser gauge) (Growth Management Scale). Body mass index (BMI) was calculated as weight (kg) divided by height squared (m\(^2\)). Waist and hip circumferences were measured by MioType, a non-stretch tape with mm precision as described elsewhere [32-33]. Systolic and diastolic BP and heart rate measurements were taken three times in the right arm on a sitting position, using a universal cuff and automatic BP and heart rate monitors (Boso Medicus Uno, Bosch+Sohn GmbH, Jungingen, Germany). The first measurement was ignored, the mean of second and third measurements being taken for analysis. The measurements were taken after the participant had rested for 15 minutes and each with three minutes of rest between the measurements (maximum deviation of cuff pressure measurement ± 3 mmHg and of pulse rate display ± 5%). Hypertension is defined as systolic and/or diastolic BP ≥140/90 mmHg or regular antihypertensive treatment [36].

A single 24h urine collection was obtained from the participants. Each participant was given a leaflet with explanations along with the necessary equipment and a record sheet on which participant noted the start and the finish times of their urine collection, any missed urine aliquots and any medication taken during the collection. The participants were carefully instructed on urine collection methodology [32-33]. In an effort to minimize bias, participants were also requested not to change their diet before or during the day of the urine collection. The first void upon waking on the day of collection was discarded. The urine volume of the 24h collection was measured by field team-members and a urine sample was stored in a cool place for a maximum of 24h until transportation to the laboratory. Sodium, potassium and creatinine determinations were carried out immediately [37-38]. Sodium and potassium concentration in the urine samples were determined using a Ion Selective Electrode with a Beckman Coulter Synchron CX5PRO System and expressed in mmol/L [37]. Creatinine concentration was determined through the Creatinine (urinary) Jaffé kinetic method and expressed in mg/dL [38]. These determinations were carried out at the ICS Medical Laboratory Synevo SRL in Chişinău. Urinary iodine was measured separately at the National Agency for Public Health of the Republic of Moldova using the ammonium persulfate digestion method with spectrophotometric detection by Sandell-Kolthoff reaction, expressed as mcg/L [39]. Iodine determinations in table salt were carried out by the titration method [40].

2.3 Statistical Analysis

All statistical analyses were performed using the SPSS software, version 20 (SPSS Inc., Chicago, IL, USA). To detect approximately 1 g reduction in salt intake over time using 24h urinary sodium excretion (difference ~20 mmol/L/24h), with a standard deviation of 75 mmol/L/day (alpha = 0.05, power = 0.80), a minimum sample of 120 individuals per stratum is recommended [32-33]. Thus, a minimum recommended sample size of 240 was estimated per age and sex groups and adjusted for an anticipated non-response rate of 50% [32-33]. The population was stratified in groups by sex (men
and women), age (18-29 years, 30-44 years, 45-59 years, 60-69 years) and urban/rural areas. Therefore 1,920 individuals were originally needed to be selected (total n=120*8 groups/0.5 attrition=1,920). T-test for unpaired samples or analysis of variance (ANOVA) was used to assess differences between group means. Pearson chi-square test was used to test the association between categorical variables. To convert urinary output into dietary intake, the urinary excretion of sodium (UNa) or potassium (UK) values (mmol/day) were first converted to mg/day (for sodium 1 mmol = 23 mg of sodium, for potassium 1 mmol = 39 mg). The conversion from dietary sodium (Na) intake to salt (NaCl) intake was made by multiplying the sodium value by 2.542. Then, sodium values were multiplied by 1.05 (assuming that only 95% of sodium ingested is excreted). For potassium dietary intake was calculated assuming three scenarios (70%, 85% or 95% of the potassium ingested is excreted in the urine). Urinary iodine was expressed in mcg/day. We used the cut-off targets for iodine consumption set by the World Health Organization (based on urinary iodine concentrations in mcg/L derived from 24h collections) [31]. The results were reported as mean (SD and/or 95%CI) or as percentages, as appropriate. Two-sided p below 0.05 were considered statistically significant.

3. Results

The final population sample included 858 participants between 18 and 69 years old (n = 326 or 38% men and n = 532 or 62% women), recruited nationally (Figure 1).

3.1 Characteristics of the Participants

The characteristics of the participants are shown in Table 1. There was no statistically significant difference in the mean age between male and female participants, however men were significantly taller and heavier than women and had a higher systolic BP. The prevalence of hypertension was on average 45.5% (385/858), comparable in men (148/326 or 45.8%) and women (237/532 or 45.2%; P > 0.05).

<table>
<thead>
<tr>
<th>Variable</th>
<th>All  (n=858)</th>
<th>Men (n=326)</th>
<th>Women (n=532)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>48.5 (13.8)</td>
<td>47.3 (13.6)</td>
<td>49.2 (13.9)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>166.7 (8.8)</td>
<td>172.8 (8.1)</td>
<td>162.9 (7.0)†</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>78.2 (15.8)</td>
<td>82.0 (15.8)</td>
<td>75.8 (15.3)†</td>
</tr>
<tr>
<td>B.M.I. (kg/m²)</td>
<td>28.1 (5.4)</td>
<td>27.4 (4.9)</td>
<td>28.6 (5.7)‡</td>
</tr>
<tr>
<td>Waist circumference (cm)</td>
<td>-</td>
<td>93.8 (15.5)</td>
<td>91.8 (15.1)</td>
</tr>
<tr>
<td>Hip circumference (cm)</td>
<td>-</td>
<td>100.5 (12.3)</td>
<td>106.5 (14.0)</td>
</tr>
<tr>
<td>Systolic BP (mmHg)</td>
<td>134.3 (21.2)</td>
<td>136.1 (18.5)</td>
<td>133.1 (22.6)§</td>
</tr>
<tr>
<td>Diastolic BP (mmHg)</td>
<td>86.8 (11.9)</td>
<td>87.1 (10.8)</td>
<td>86.6 (12.6)</td>
</tr>
<tr>
<td>Pulse rate (b/min)</td>
<td>76.2 (9.5)</td>
<td>78.0 (10.3)</td>
<td>75.2 (8.8)</td>
</tr>
<tr>
<td>Hypertension* n (%)</td>
<td>385 (45.5)</td>
<td>148 (45.8)</td>
<td>237 (45.2)</td>
</tr>
</tbody>
</table>

Results are mean (SD) or as percentage; †p<0.001; ‡p=0.002; *p=0.04 vs men.

§Systolic BP ≥140 mmHg and/or DBP ≥90 mmHg or on anti-hypertensive medications.

3.2 Daily Urinary Excretions of Volume, Sodium, Potassium and Creatinine and Salt and Potassium Intake

Average urinary volume excretion was 1441 mL per day, being higher in men than women, and higher in urban compared to rural areas (Table 2). Average urinary creatinine excretion was 11.7 mmol per day, being again higher in men than women, but lower in urban compared to rural areas (Table 2). Urinary sodium excretion showed a normal distribution with a tail skewed to the right (i.e., towards higher values). Mean urinary sodium was 172.7 (SD 79.3) mmol/24h (Table 2), equivalent to a mean consumption of 10.8 (4.9) g of salt per day (Table 2). Men excreted more sodium than women (mean difference 18.1 mmol/24h, p < 0.001), equivalent to ~1.1 g of higher salt consumption than women. Only 97 participants (11.3%) met the levels of salt intake of 5g or less recommended by the WHO, with no difference between sex and area of residence. Urinary potassium excretion showed a
normal distribution with a tail skewed to the right (i.e. towards higher values). Mean urinary sodium was 72.7 (31.5) (Table 2), equivalent to a mean consumption of 3.26 (1.6) g of potassium per day (Table 2).

**Table 2.** Daily urinary excretions of volume, sodium, potassium and creatinine and estimates of salt and potassium intake.

<table>
<thead>
<tr>
<th>Variables</th>
<th>All (n = 858)</th>
<th>Men (n = 326)</th>
<th>Women (n = 532)</th>
<th>Rural (n=531)</th>
<th>Urban (n=327)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume (mL/24h)</td>
<td>1441 (529)</td>
<td>1505 (536)</td>
<td>1401 (521)</td>
<td>1333 (427)</td>
<td>1616 (624)</td>
</tr>
<tr>
<td>Sodium (mmol/24h)</td>
<td>172.7 (79.3)</td>
<td>183.9 (86.0)</td>
<td>165.8 (74.1)</td>
<td>180.4 (80.2)</td>
<td>160.1 (76.2)</td>
</tr>
<tr>
<td>Salt intake (g/day)‡</td>
<td>3.26 (1.41)</td>
<td>3.41 (1.50)</td>
<td>3.17 (1.35)</td>
<td>3.31 (1.42)</td>
<td>3.18 (1.40)</td>
</tr>
<tr>
<td>Potassium (mmol/24h)</td>
<td>72.7 (31.5)</td>
<td>76.0 (33.4)</td>
<td>70.7 (30.1)</td>
<td>73.8 (31.6)</td>
<td>71.0 (31.2)</td>
</tr>
<tr>
<td>Potassium intake (g/day)†</td>
<td>3.26 (1.41)</td>
<td>3.41 (1.50)</td>
<td>3.17 (1.35)</td>
<td>3.31 (1.42)</td>
<td>3.18 (1.40)</td>
</tr>
<tr>
<td>Creatinine (mmol/24h)</td>
<td>11.7 (5.0)</td>
<td>13.3 (5.6)</td>
<td>10.7 (4.2)</td>
<td>12.3 (4.8)</td>
<td>11.4 (5.0)</td>
</tr>
</tbody>
</table>

Results are mean (SD). †p<0.001; ‡p<0.005; *p<0.01; †p<0.02 vs men or vs rural; .

Men excreted more potassium than women. Between 31% and 50% of participants (on the three different assumptions) met the levels of potassium intake of 90 mmol/day or more recommended by the WHO, with no difference between sexes and areas of residence.

### 3.3 Daily intake of iodine and use of iodised salt

Urinary iodine excretion (as measure of intake) was adequate in 40.9% of participants, irrespective of sex or area of residence (Table 3). Iodine consumption was above requirement or excessive in 30.3% of the participants, irrespective of sex or area of residence. Of the 28.6% who fell into the category indicating insufficient consumption (equally distributed by sex or area of residence), only 2.3% had severe deficiency (Table 3).

**Table 3.** Proportions of participants meeting WHO targets for iodine consumption (based on urinary iodine concentrations in mcg/L derived from 24h collections).

<table>
<thead>
<tr>
<th>Group (mcg/L)</th>
<th>All (n = 858)</th>
<th>Men (n = 326)</th>
<th>Women (n = 532)</th>
<th>Rural (n=531)</th>
<th>Urban (n=327)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insufficient (&lt;100)</td>
<td>245 (28.6)</td>
<td>95 (29.1)</td>
<td>150 (28.2)</td>
<td>104 (31.8)</td>
<td>141 (26.6)</td>
</tr>
<tr>
<td>Severe (&lt;20)</td>
<td>20 (2.3)</td>
<td>6 (1.8)</td>
<td>14 (2.6)</td>
<td>4 (1.2)</td>
<td>16 (3.0)</td>
</tr>
<tr>
<td>Moderate (20-49)</td>
<td>60 (7.0)</td>
<td>24 (7.4)</td>
<td>36 (6.8)</td>
<td>28 (8.6)</td>
<td>32 (6.0)</td>
</tr>
<tr>
<td>Mild (50-99)</td>
<td>165 (19.2)</td>
<td>65 (19.9)</td>
<td>100 (18.8)</td>
<td>72 (22.0)</td>
<td>93 (17.5)</td>
</tr>
<tr>
<td>Adequate (100-199)</td>
<td>351 (40.9)</td>
<td>132 (40.5)</td>
<td>219 (41.2)</td>
<td>131 (40.1)</td>
<td>220 (41.4)</td>
</tr>
<tr>
<td>Above requirement (200-299)</td>
<td>152 (17.7)</td>
<td>59 (18.1)</td>
<td>93 (17.5)</td>
<td>58 (17.7)</td>
<td>94 (17.7)</td>
</tr>
<tr>
<td>Excessive (≥300)</td>
<td>108 (12.6)</td>
<td>40 (12.3)</td>
<td>68 (12.8)</td>
<td>34 (10.4)</td>
<td>74 (13.9)</td>
</tr>
</tbody>
</table>

Results are number (%).

Average urinary iodine excretion was 225 (SD: 152) mcg per day (Table 4) (median 196 mcg per day), with no difference between sexes or areas of residence. Iodine salt content was, on average 21.0 (18.6) mg/kg, with no difference between men and women. However, participants in rural areas consumed table salt with significantly less iodine concentrations than those samples consumed in urban areas (p < 0.001; Table 4).
Table 4. Daily urinary excretions of iodine and iodine content of household salt samples.

<table>
<thead>
<tr>
<th>Variables</th>
<th>All (n = 858)</th>
<th>Men (n = 326)</th>
<th>Women (n = 532)</th>
<th>Rural (n=531)</th>
<th>Urban (n=327)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iodine (mcg/24h)</td>
<td>225 (152)</td>
<td>232 (154)</td>
<td>221 (150)</td>
<td>225 (145)</td>
<td>224 (128)</td>
</tr>
<tr>
<td>Iodine in table salt (mg/kg)</td>
<td>21.0 (18.6)</td>
<td>22.1 (18.2)</td>
<td>20.3 (18.9)</td>
<td>16.7 (18.6)</td>
<td>28.1 (16.5)*</td>
</tr>
</tbody>
</table>

Results are mean (SD). *p<0.001 vs rural

There was a weak correlation between the amount of sodium excreted in the urine and the amount of excreted iodine (Figure 3). No difference was noted between men and women or rural and urban settings.

Figure 3. Correlations between urinary sodium and urinary iodine excretions by sex (left) and areas of residence (right). Overall Pearson r=0.087; p=0.01

There was also a weak correlation between the amount of urinary iodine excreted in a day and the amount of iodine present in the table salt sampled from the households of individual participants (Figure 4). No significant differences in these correlations were noted between men and women and rural and urban settings, despite the fact that table salt in rural areas contained less iodine (Table 4).

Figure 4. Correlations between urinary iodine excretions and iodine content of household’s table salt by sex (left) and areas of residence (right). Overall Pearson r=0.024; p=0.486

3.4 Knowledge, Attitude and Behaviours Towards Salt Intake

Knowledge, attitude and behaviours toward the consumption of salt was 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 towards dietary salt. A total of 35.4% of respondents mentioned that they added salt always or often before or while eating. The percentage of men who added salt always or often to their meal was significantly higher than that of women (47.8% vs 27.7%; p<0.001). A total of 61.3% of respondents reported that they always or often added salt when cooking or...
preparing food at home; this was the case more often in rural than in urban areas (69.8% vs 47.5%; \( p < 0.001 \)). More than half of the respondents (64.4%) mentioned that they used iodised salt when cooking or preparing food at home. Consumption of iodised salt, however, was higher in urban than in rural areas (86.1% vs 52.9%; \( p < 0.001 \)). About a quarter (26.7%) felt they consumed too much or far too much salt, women being more likely (32.1% vs 23.3%; \( p < 0.01 \)). More than half of the respondents (64.4%) mentioned that they used iodised salt when cooking or preparing food at home. Consumption of iodised salt, however, was higher in urban than in rural areas (86.1% vs 52.9%; \( p < 0.001 \)).

Participants were asked about actions they take to control salt intake on a regular basis. A total of 81.7% limited their consumption of processed food high in salt (Table 5). 22.3% would use spices rather than salt, 1 in 3 would not add salt when cooking. Only 8% looked at salt/sodium content on food labels and 14.3% bought alternatives to salt. One in three avoided eating food prepared outside home and 0.8% took any other measure to reduce salt intake.

### Table 5. Knowledge, attitudes and behaviour towards the consumption of salt.

<table>
<thead>
<tr>
<th>Participants who:</th>
<th>All (( n = 858 ))</th>
<th>Men (( n = 326 ))</th>
<th>Women (( n = 532 ))</th>
<th>Rural (( n = 531 ))</th>
<th>Urban (( n = 327 ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limit their consumption of processed food</td>
<td>81.7</td>
<td>79.7</td>
<td>82.4</td>
<td>80.4</td>
<td>83.9</td>
</tr>
<tr>
<td>Look at salt/sodium content in foods</td>
<td>8.8</td>
<td>10.1</td>
<td>8.2</td>
<td>3.8</td>
<td>17.2*</td>
</tr>
<tr>
<td>Buy low salt/sodium alternatives</td>
<td>14.3</td>
<td>17.4</td>
<td>13.2</td>
<td>3.8</td>
<td>24.7*</td>
</tr>
<tr>
<td>Do not add salt at the table</td>
<td>77.3</td>
<td>69.6</td>
<td>80.2</td>
<td>75.9</td>
<td>79.6</td>
</tr>
<tr>
<td>Do not add salt when cooking</td>
<td>31.1</td>
<td>24.6</td>
<td>33.5</td>
<td>13.3</td>
<td>61.3*</td>
</tr>
<tr>
<td>Use spices instead of salt when cooking</td>
<td>22.3</td>
<td>15.9</td>
<td>24.7</td>
<td>25.3</td>
<td>17.2</td>
</tr>
<tr>
<td>Avoid eating food prepared outside a home</td>
<td>33.1</td>
<td>27.5</td>
<td>35.2</td>
<td>43.7</td>
<td>15.1*</td>
</tr>
<tr>
<td>Take other measures to control salt intake</td>
<td>0.8</td>
<td>1.4</td>
<td>0.5</td>
<td>1.3</td>
<td>0</td>
</tr>
</tbody>
</table>

Results are expressed as % of column total. *\( p < 0.001 \) vs rural by Fisher’s exact test

### 4. Discussion

This is the first national survey on sodium, potassium and iodine consumption ever carried out in adults in the Republic of Moldova, using the gold standard measure of 24h urinary sodium, potassium and iodine excretions as biomarkers of intake. The results show unequivocally that salt consumption is high, potassium consumption is lower than recommended, both in men and in women. Furthermore, iodine intake is still inadequate in 1 in 3 people, although severe iodine deficiency is rare. However, universal salt iodization cover is still inadequate in many households both in urban and rural areas, where the use of iodized salt is still limited in the Moldovan diet.

#### 4.1 Salt consumption

Average salt intake was nearly 11 g per day, over twofold the WHO recommended maximum population target of 5 g per day [14]. Only 11.3% of the participants met the WHO salt targets. Men excreted more sodium than women, and in rural areas salt consumption was higher than in urban areas. Discretionary use of salt is common in the Republic of Moldova, with a third of participants adding salt regularly to food and half also using it regularly when cooking. The majority of participants knew that high salt causes serious health problems. However, only less than half thought it would be useful to reduce its consumption, and even fewer felt their own intake was not excessive and were doing anything to reduce it. The answers to these questions reveal an insufficient level of knowledge of the problem associated with high salt consumption amongst the participants and the unreadiness to transfer this knowledge to behavioural changes in using discretionary salt.
4.2 Potassium consumption

Average population potassium intake was estimated at around 3.26 g per day, still lower than the WHO recommended minimum population target of 3.51 g per day (equivalent to 90 mmol per day [27]. Between 31% and 50% met WHO potassium targets. Men ate more potassium than women, likely due to the larger body size and volume of food eaten, rather than the quality of it. Salt and potassium are expressed as total quantities rather than consumption per calorie intake, hence the gender difference is mainly explained by the larger body size of men compared to women and the corresponding total food consumption compared to women. No difference in potassium intake was detected between rural and urban areas.

4.3 Iodine consumption

Average daily iodine consumption was 225 mcg per day, with no difference between sexes or areas of residence. Severe iodine deficiency (<20 mcg/L according to WHO criteria [31]) was rare. However, more than a quarter had levels below 100 mcg/L (insufficient), and a quarter had levels either above requirement or excessive (above 300 mcg/L). The Republic of Moldova has adopted for a long time a policy of universal salt iodization for the control of iodine deficiency disorders [28]. It should be mentioned that as from 2009 the production and placing on the market of iodized bottled water was authorised by the Government, which may have contributed to the increasing iodine supply, especially among more affluent population groups. By measuring the iodine content of the table salt used in the households visited for the screening, we were able to detect a significant lower iodine content in rural compared to urban areas (16.7 vs 28.1 mg/kg). Moreover, the percentage of households with no iodized salt was greater in rural than urban areas (30.9% vs 9.8%; p<0.001). A significant finding in our study was the lack of strong relationships between urinary sodium and iodine excretions and between urinary iodine excretion and iodine content in households’ table salt. These findings indicate that the majority of salt in the Moldovan diet derives from non-iodized sources. Assuming that the food eaten in the households is prepared with iodized salt (since the country has a national policy of universal salt iodization), a major component of the salt consumed may derive from food eaten outside the household prepared with non-iodized salt. These results seem to suggest a variety of barriers, including possibly deterioration of iodized salt before reaching the users, reduced access, lower use, lack of awareness, costs, lack of use of iodized salt in food preparation by local producers, street vendors and food industry.

4.4 Comparison with other European countries

Our main findings show that the salt intake in the Republic of Moldova is as high or higher than that reported in many other European and neighbouring countries, both in men and women. In the recent MINISAL study in Italy, the daily salt intake of Italians was 10.9 g for men and 8.5 g for women [41], with large variations by region and socio-economic status [42]. In northern Greece average intakes were 11.1 and 9.1 g per day for men and women, respectively [43]. In the national survey of salt consumption in Slovenia men ate 13.0 g and women 9.9 g per day [21]. Recently, in the city of Podgorica, in Montenegro, salt consumption was measured at 13.9 g in men and 9.9 g per day in women [22]. In the SALTURK II survey in Turkey, men consumed 15.7 g of salt per day and women 14.0 g per day, with higher salt consumption in rural compared to urban areas [44]. Finally, in Portugal a national survey as estimated the consumption of salt at 10.7 g per day in men and 10.2 g per day in women [45].

Potassium intake in the Republic of Moldova was lower than in Portugal [45] and higher than that measured in Italy [41], Greece [43] and Montenegro [22]. Men eat more potassium than women.

4.5 Strengths and Limitations

Strengths of our study are the inclusion of a large random sample of male and female participants representative of the Republic of Moldova, the assessment of average consumption of
salt and potassium by 24h urine collection (gold-standard measure of salt and potassium intake) [33], the rigorous quality control and the careful standardized protocol of urine collections. In particular, the rigorous instructions to ensure completeness of urine collections and the strict protocol to select for analysis only those fulfilling the quality control criteria among which the length of collection time and the assessment of urinary creatinine excretion, markers of the accuracy of the collection. Our study is one of few studies having carried out at the same time a population based evaluation of daily iodine excretion in an adult population using 24h urinary iodine excretion as a biomarker (rather than spot urine samples), to assess the iodine status of a group of individuals who, whilst being supplemented with the universal salt iodization program, is not usually included in the population monitoring and surveillance on the effects of such policy.

The study has some limitations. The possibility of selection bias cannot be excluded. We excluded a third of the participants as a result of the robust quality control for completeness of urine collections. Participants not delivering complete urines had lower weight, BMI, waist and hip circumferences and lower diastolic BP than those complying. No other differences were seen in their general characteristics (Supplementary material). Urinary sodium and potassium excretions were only assessed once. Given the large within-subject variability in consumption, it is acknowledged that a single collection is unlikely to characterize an individual’s salt and potassium consumption [46]. However, group estimates are less likely to be biased by this variability.

4.6 Impact and Policy implications

The population of the Republic of Moldova is of just over 4 million, of whom approximately 75% over the age of 25 years. According to national health statistics from 2016, the mortality rate from diseases of the cardiovascular system is 617.3 per 100,000 population [47]. To meet the 30% reduction in population salt consumption set by the World Health Organization, the Republic of Moldova should aim at a 3.24 g per day reduction nationally. This reduction would be expected to avert 7.9% CVD events and 10.7% strokes every year, approximately 1,460 CVD deaths per year.

The Republic of Moldova adopted the National Strategy on Prevention and Control of Noncommunicable Diseases 2012-2020 and its Action Plan [48]. Part of this pledge is to continue on the awareness campaigns already in place and to establish a comprehensive strategy involving legal measures, mandatory reformulation, nutritional labelling, efficient enforcement and good leadership [28]. Furthermore, a feasibility study of implementation and evaluation of essential interventions for the prevention of CVD in primary healthcare is currently under way in the Republic of Moldova, with a view towards a national scale-up [49].

The evidence of the level of sodium and potassium intake in the Republic of Moldova provides robust evidence to support action and to facilitate evaluation. Awareness, attitudes and behaviours about salt and its implication for health suggest that there is an intensification of public awareness campaigns and health promotion to improve the take up of preventive strategies aiming at reducing salt consumption, whilst at the same time increasing potassium intake by encouraging higher consumption of potassium-rich food. Awareness about hidden salt in processed food should be highlighted. The national program for reducing salt intake in the Republic of Moldova needs a multisectoral collaborative approach including not only public awareness and behaviour-change communication (including via health care professionals), but, more importantly, structured programs for reformulation that set the framework for the food industry to reduce salt in bread and bakery products and processed foods, major source of salt intake.

The present study provides valuable insights into ways to improve and adapt the universal salt iodization program. From one hand our results suggest that there are improvements to be made for a comprehensive take up of the policy nationally. On the other hand it confirms that both iodization and salt reduction policies are fully compatible, as agreed in a WHO Consensus Statement [31] and more recently confirmed in case studies in Italy [50] and China [51] where a moderate salt reduction in unlikely to compromise iodine status. Our data provides a useful baseline against which to monitor the impact of future initiatives.

Supplementary Materials: The following are available online at http://www.mdpi.com/......

Table S1. Characteristics of the excluded participants and comparison with those included in the study.

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Author Contributions: FPC developed the protocol, trained local teams, co-ordinated quality control and data analysis and drafted the manuscript. LD carried out quality control and statistical analysis. GO and AC developed the research protocol, trained local teams, coordinated the study, carried out the fieldwork and liaised with the local laboratory. JJ and JB contributed to the design and interpretation of the findings. All authors contributed significantly to the final version of the manuscript.

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Conflicts of Interest: 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. AC, JJ and JB are staff members of the World Health Organization. FPC is a technical advisor to the World Health Organization, unpaid member of Action on Salt and WASH. GO has no conflict of interest to declare.

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https://www.who.int/nchs/surveillance/steps/STEPS_Instrument_v2.1.pdf


