MEASURING POPULATION SALT INTAKE

Measuring population salt intake is crucial baseline data for the development of a salt reduction strategy. It helps to define the scale of the issue and build a case for a nationwide public health programme. Over time, monitoring trends in population salt intake is a necessary step in evaluating the effectiveness of the intervention. More than 90% of salt eaten is passed in urine and therefore the most accurate measurement of salt intake is to collect 24-hour urine samples from a representative sample of the population.

24-hour Urine Measurement

The recognised gold-standard method of measuring population salt intake is through 24-hour urine measurements, ideally over several days to account for the daily change in salt intake but one 24-hour urine measurement is considered sufficient for population surveys. It is strongly recommended that 24-hour urine analysis is conducted, as it is the least biased method of measuring salt intake; where available, resources should be put towards reliable methods which will provide the best quality data.

Several protocols exist which give clear guidance on measuring salt intake via 24-hour urinary sodium analysis, including a detailed protocol from the WHO Eastern Mediterranean Regional Office [2],[3].

A NOTE ON IODINE

It is feasible and achievable to reduce population salt intake without impacting iodine status [1]. However, there are concerns that interventions to reduce dietary salt consumption could have a negative effect on programmes to prevent iodine deficiency disorder, where salt is used as a carrier of iodine. In order to address this, it is recommended that iodine intake be assessed along with salt.

Target Population
The target population should be a random sample of adults or children, depending on the aims of the salt intake assessment. To avoid bias or ethical issues, the following exclusion criteria should be used:

- people unable to provide informed consent
- those with a known history of heart or kidney failure, stroke, liver disease
- those who recently began therapy with diuretics (less than two weeks prior to the proposed urine sample collection date)
- any other conditions that would make 24-hour urine collection difficult

Sample Size
Participant recruitment should be done using a stratified random sampling method to ensure the sample is representative of strata defined by urban/rural areas, age and gender.

In general, to detect approximately 1 g reduction in salt intake over time using 24-hour urinary sodium excretion, with a variation (standard deviation) of 75 mmol/day (alpha = 0.05, power = 0.80), a minimum sample of 120 individuals per age and sex stratum is recommended (see below). To account for participant drop out or incomplete urine collections, which may be as high as 50%, up to 240 people per age and sex stratum should be invited to participate [2].

Conducting the Measurement
Efforts must be made to ensure every drop of the urine is collected, with a clear start and end time of the 24-hour urine collection recorded.

- All participants should be given both oral and printed instructions on how to accurately collect 24-hour urine. Please refer to WHO Regional Office for the Eastern Mediterranean Regional Office's document for an example of the detailed information sheet that should be given to participants [2]. Each participant will be provided with:
  - A 5 litre screw-capped plastic collection bottle containing a preservative
  - A spare collection bottle will be offered for participants who anticipate leaving home during the collection period
  - A 1 litre plastic jug and funnel
  - Plastic carrier bags to transport the equipment away from home
  - Stickers to be attached to underclothes or nightwear as a reminder for urine collection
  - Sheet to record the start and finish times of 24-hour urine collection and information about any missed samples
- Timing/days: The collection will be made on a weekday or weekend at the individuals' choice to maximise participation rates
- Urine collection:
  - At the start of the 24-hour period, the participant will void the bladder and note the time. All urine passed thereafter should be collected in the container provided, including the last urine, i.e. 24 hours after starting the urine collection, with the final time recorded
  - Participants should pass all urine directly into the 1 litre plastic jug, with the use of the funnel for women, then pour the urine into the collection container using the funnel
  - Each time urine is added to the urine collection bottle, participants will need to screw the lid tight and swirl it around a few times, so as to mix the preservative
  - Participants should be asked to take the spare urine bottle with them if they plan to go somewhere else instead of staying at home. Any urine collected in this spare bottle must be added to the main collection bottle as soon as possible after returning home
  - If the participants miss a urine collection or spillages occur, they should be asked if they can provide a new 24-h urine

Analysis
Sodium, potassium (if relevant), iodine (if relevant) and creatinine content in the urine should be measured in a recognized laboratory. Creatinine is measured to assess completeness of the 24-hour urine collection [4].

For reference, the following analytic methods can be used [2],[3]:
- Sodium and potassium content in the urine may be determined through Ion Selective Electrode (indirect) methodology using.
- Creatinine content may be determined through the Creatinine (urinary) Jaffe kinetic method, standardized.
- Iodine content (if relevant for the Region/country) in urine may be determined with the traditional kinetic Sandell-Kolthoff method or by Inductively Coupled Plasma (ICP) Spectrometry.

Calculating Salt Intake
From the sodium content (mmol per litre), 24-hour urinary sodium can be calculated as [5]:
- Urinary sodium (mmol/24-hour) = sodium (mmol/litre) x urinary volume (litre per 24-hour)

As 1g of salt = 17.1 mmol of sodium, salt intake can then be calculated as:

- Salt (g/day) = 24-hour urinary sodium (mmol/24-hour) / 17.1

Example from Tunisia

In Tunisia, 24-hour urinary sodium excretions were measured in a sample of 194 adults. The original sample population was 420 adults, but many samples did not meet the completeness criteria, a common issue in assessing 24-hour urinary sodium [6].

Spot Urine Measurement

If resources are limited, it is possible to estimate salt intake through spot urine measurements, i.e. one sample of urine collected from each participant which is then converted to daily salt intake via the use of an equation. Salt intake varies throughout the day and so estimating salt intake via spot urine measurements is not recommended unless 24-hour urine measurement has been carried out, alongside spot urine, at baseline. If spot urine measurements are used, similar consideration should be given to target population and sample size as 24- hour urine measurement above.

Conducting the Measurements

Each participant should be provided with:

- a screw-capped plastic sample bottle
- a 1 litre plastic jug and funnel

Participants will pass all urine directly into the 1 litre plastic jug, with use of the funnel for women, then pour the urine into the sample bottle using the funnel. The collection can be made on a weekday or weekend at the individuals' choice to maximise participation rates.

Analysis

Urinary sodium, potassium (if relevant) and creatinine concentrations should be measured in the laboratory, as above. 24- hour urinary sodium, potassium and creatinine excretion is then estimated using one of the following equations.

Estimating 24-hour urinary sodium excretion, mmol/24h	
INTERSALT [7]	spot K (mmol/L)]+[4.10 x BMI (kg/m2)] + [0.26 x age (yr)]} Women: = 23 x {5.07 + [0.34 x spot Na (mmol/L)]- [2.16 x spot Cr (mmol/L)]-[0.09 x spot K (mmol/L)]+[2.39 x BMI (kg/m2)] + [2.35 x age (yr)]-[0.03 x age2 (yr)]}
Kawasaki [8]	=23 x (16.3 x XNa0.5) Where: XNa = [spot Na (mmol/l) / spot Cr (mg/dL) x 10] x PrCr*(mg/day) PrCr (mg/day) = • Men: [-12.63 x age (y)] + [15.12 x WT (kg)] + [7.39 x HT (cm)]-79.9 • Women: [-4.72 x age (y)] + [8.58 x WT (kg)] + [5.09 x HT (cm)]-74.5
Tanaka [9]	=23 x (21.98 x XNa0.392) Where: XNa = [spot Na (mmol/l) / spot Cr (mg/dL) x 10] x PrCr PrCr (mg/day) = [-2.04 x age (y)]+ [14.89 x WT (kg)] + [16.14 x HT (cm)]-2244.45

Toft [10]	Men: 33.56 x XNa0.345 Women: 52.65 x XNa0.196 Where: XNa = spot Na/spot Cr x PrCr PrCr = • Men: -7.54 age (years) + 14.15 (kg) + 3.48 height (cm) + 423.15 Women: -6.13 age (years) + 9.97 weight (kg) + 2.45 height (cm) + 342.73
Estimating 24-hour urinary creatinine excretion, mg/24h	
Kawasaki [8]	Men: −4.72×age + 8.58×weight (kg) + 5.09×height (cm) − 74.5 Women: −12.63×age + 15.12×weight (kg) + 7.39×height (cm) − 79.9
Tanaka [9]	−2.04×age + 14.89×weight (kg) + 16.14×height (cm) − 2244.45
Estimating 24-hour urinary potassium excretion, mg/24h	
Kawasaki [8]	7.2 × [spot Na (mmol/l)/spot Cr (mmol/l) × estimated 24-hour urinary Cr (mg)]0.5
Tanaka [9]	7.59 × {[(spot K (mmol/l)/spot Cr (mg/dl)×10] × [estimated 24-hour urinary Cr (mg)]}0.431

NOTE:

- Spot Na = spot urine sodium
- Spot Cr = spot urine creatinine
- Spot K = spot urine potassium
- PrCr = predicted 24-hour creatinine excretion from age, weight and height
- BMI = body mass index

Evidence shows that all equations introduce bias into calculations of salt intake – one equation is not more accurate than another [11],[12]. The Kawasaki and Tanaka equations were developed in Japanese populations, and studies utilising all equations have traditionally taken place in Europe or USA, with limited studies in Eastern Mediterranean countries [13]. Therefore, any equation could be used, with the understanding that the results will be less accurate than a 24-hour urinary sodium measurement. To verify the spot urine results, 24-hour urinary measurements in a sub-sample of participants can be conducted and compared to results achieved through spot urine measurements at baseline. Spot urine can also be used to monitor the changes of salt intake over time.

Spot urinary sodium to monitor relative changes in population salt intake

Recent research, using data from UK 24-hour urine surveys and spot urine surveys, suggests that the average sodium concentration from spot urines collected from an independent random sample of the population, used without the equations described above, could reflect percentage changes in population salt intake [14]. This has practical implications for measuring population salt intake.

Monitoring population salt intake would thus ideally consist of collecting 24-hour urine surveys regularly, e.g. every 3-5 years, complemented with spot urine surveys every 1-2 years in between.

While the 24-hour urine surveys remain the most accurate way to assess population salt intake, the more frequent spot urine surveys would allow for a closer monitoring of percentage changes in population salt intake, thus providing more immediate feedback on the effectiveness of any ongoing salt reduction programme. Spot urine samples could be used to monitor relative changes in population salt intake to begin with, and the baseline salt intake (in grams per day) could be retrospectively calculated at a later stage, when the necessary resources will have been gathered to carry out a 24-hour urine survey.

Method	Advantages	Disadvantages
24-hour urine measurement	• The most accurate method of measuring average population salt intake • Captures 90% of total sodium consumed • Provides accurate measure of total salt consumed in a whole day i.e. not specific to a single point/meal in time • ·Can complement iodisation programmes to prevent iodine deficiency, as it can be used at the same time for monitoring total iodine intake • Provides an accurate baseline measurement, allowing for ongoing spot urine measurements to track changes in salt content over time	• More burdensome for participants which could result in low participation rates and/or under collection of urine
Spot urine measurement	• Less burdensome for participants • Can be useful for tracking changes in salt intake overtime • Requires less training for staff	• Does not produce accurate measurement of salt intake • Highly dependent on several variables at the individual level - time, hydration, duration/volume of collection, high proportional residual bladder volume • Does not provide an absolute measure of salt intake at baseline, so is less desirable for the initiation of monitoring programs of population salt reduction.

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