Dietary sources of sodium and urinary sodium excretion in Maputo, Mozambique

Ana Rui Faria de Queiroz
Dissertação de Mestrado apresentada à Faculdade de Ciências da Universidade do Porto. Faculdade e Ciências da Nutrição e Alimentação da Universidade do Porto
Mestrado em Ciências do Consumo e Nutrição
2016
Dietary sources of sodium and urinary sodium excretion in Maputo, Mozambique

Ana Rui Faria de Queiroz
Mestrado em Ciências do Consumo e Nutrição
Departamento Geociências, Ambiente e Ordenamento de Território
2016

Orientador
Patrícia Padrão, Professora Auxiliar, Faculdade de Ciências da Nutrição e Alimentação da Universidade do Porto

Coorientador
Pedro Moreira, Professor Catedrático, Faculdade de Ciências da Nutrição e Alimentação da Universidade do Porto
Todas as correções determinadas pelo júri, e só essas, foram efetuadas.

O Presidente do Júri,

Porto, _____ / _____ / _______
Agradeço

Ao Professor Luís Cunha por ter exigido sempre mais dos seus alunos durante esta etapa como diretor de mestrado.

A todos os coautores do artigo aqui apresentado, pelo contributo para a sua realização. Foram peças fundamentais.

Ao Professora Pedro Moreira por ter auxiliado na elaboração e correção do artigo.

À Professora Patrícia pela pedagogia e generosidade com que me transmitiu e partilhou os seus conhecimentos e por me orientar como se da sua tese se tratasse. Por escutar todas as dúvidas sem nunca as pôr em causa. Agradeço ainda a paciência e o empenho. Não podia ter escolhido melhor.

À Sofia Sousa por ser a amiga com quem partilhei toda esta experiência e que muitas vezes me socorreu.

Aos meus amigos, por sem saberem, permitirem ultrapassar os momentos de fraqueza com momentos de descontração.

À Rita por estar sempre disponível.

Ao Igor por toda a paciência e motivação, pelo apoio incondicional.

Aos meus pais e irmão, por tudo!
Abstract

The changes in eating habits have been linked to the occurrence of noncommunicable diseases (NCDs) in developing countries such as Mozambique. These changes are strongly related to globalization, industrialization and urbanization and they are already felt in this country. Among NCDs, cardiovascular diseases (CVDs) are the leading cause of death worldwide and has had a great impact in Mozambique. Major risk factors to CVDs such as high sodium intake must be prevented and controlled. This thesis aimed to evaluate the urinary excretion of sodium, to estimate its main food sources and to quantify the contribution of processed/ultra-processed for total sodium intake in a sample of the Maputo inhabitants. With this purpose, a structured questionnaire was applied to assess demographic characteristics including sex, age, and education; anthropometric measurements were taken, a 24-h recall was applied, and 24-hour urine was collected. It was found that almost all of the participants (93%) exceeded the sodium intake recommendations; the major dietary sources for non-discretionary salt were cereal and meat products, contributing with 66% and 8% respectively. Discretionary salt contributed most to total dietary intake (57%), followed by foods’ intrinsic sodium (25%) and sodium from processed foods (18%). Through Monteiro et al categorization, ultra-processed foods contributed with the huge slice of total dietary sodium intake (79%). Another important result was the failure to comply the recommended potassium intake (63%). This thesis provided the first assessment of dietary sources of sodium and urinary sodium, highlighting the need to develop more studies including other settings and also to develop programs of prevention and intervention to improve dietary habits and, in order to avoid the expected increase of NCDs.

Keywords: noncommunicable diseases, epidemiological transition, cardiovascular diseases, hypertension, dietary sodium, urinary sodium, Mozambique.
Resumo

Nos países em desenvolvimento, as alterações dos padrões alimentares contribuem para o aparecimento das doenças não transmissíveis (DNT), como verificado em Moçambique. Estas alterações estão fortemente relacionadas com o processo de globalização, industrialização e urbanização já presente neste país. Dentro das DNT, as doenças cardiovasculares (DCV) são a principal causa de morte em todo o mundo e têm tido um impacto significativo em Moçambique. A prevenção e controlo dos principais fatores de risco envolvidos neste tipo de doenças, como o elevado consumo de sal, são de extrema importância. Esta dissertação pretende avaliar a excreção urinária de sódio, estimar as principais fontes e quantificar o contributo dos alimentos processados e ultra-processados para o sódio total numa amostra de indivíduos Moçambicanos. Assim, um questionário devidamente estruturado foi aplicado para recolher informação sobre as características demográficas como sexo, idade e educação; as avaliações antropométricas foram realizadas bem como o recordatório alimentar e urinário às 24 horas anteriores. Os resultados mostraram que quase toda a amostra excedeu as recomendações relativas à ingestão de sódio (93%); as principais fontes alimentares de sódio foram os produtos cerealíferos e os de carne, contribuindo com 66% e 8% respectivamente. O sal de adição foi o principal contribuidor para a ingestão total de sódio (57%), seguido do sódio intrínseco aos alimentos (25%) e sódio proveniente dos alimentos processados (18%). Segundo a categorização de Monteiro, os alimentos ultra-processados foram os que mais contribuíram para a ingestão total de sódio (79%). Outro resultado não menos importante foi o não cumprimento das recomendações para a ingestão de potássio em que mais de metade da amostra apresentou valores abaixo do recomendado (63%). Esta tese apresenta os primeiros resultados sobre as fontes alimentares de sódio e do sódio urinário, reforçando a necessidade do desenvolvimento de mais estudos em amostras representativas, e ainda a criação de programas de prevenção e intervenção para que haja uma melhoria nos hábitos alimentares, de forma a evitar o aumento expectável das DNT.

Palavras-chave: doenças não transmissíveis, transição epidemiológica, doenças cardiovasculares, hipertensão, sódio intrínseco, sódio excretado, Moçambique.
Table of contents

AGRADEÇO .................................................................................................................. VIII

ABSTRACT ................................................................................................................... II

RESUMO ....................................................................................................................... III

LIST OF FIGURES ....................................................................................................... V

ABBREVIATIONS ......................................................................................................... VI

1. BACKGROUND ....................................................................................................... 1

1.1 Burden of noncommunicable diseases in Africa ......................................................... 4

1.2 Nutritional, epidemiological and demographic transitions ........................................ 4

1.3 The Mozambique case ............................................................................................ 7

1.3.1 Mozambique country profile ................................................................................ 7

1.3.2 Noncommunicable diseases in Mozambique ........................................................ 9

1.3.1 Hypertension and sodium in Mozambique ............................................................ 14

2. AIMS ....................................................................................................................... 17

3. METHODS ............................................................................................................. 17

3. PAPER .................................................................................................................... 21

4. CONCLUSIONS ................................................................................................... 44

5. REFERENCES ....................................................................................................... 44
List of figures

Figure 1 | Percentage of total deaths due to communicable, maternal, neonatal and nutritional diseases in 1990 and 2014, by world region…………………………………………………………..1

Figure 2 | Percentage of total deaths due to noncommunicable diseases, in 1990 and 2014, by world region………………………………………………………………………………………………………..2

Figure 3 | Proportion urban population by income groups, 1950-2050…………………………………….5

Figure 4 | The risk factors that most affect the health in the entire world…………………………………..6

Figure 5 | Population pyramid from Mozambique, 2014…………………………………………………………….8

Figure 6 | Percentage of total deaths due to communicable diseases, noncommunicable diseases and injuries in 1980 and 2013, in Mozambique……………………………………………………….9

Figure 7 | Percentage of total deaths due to noncommunicable diseases in 2013, by age group………………………………………………………………………………………………………10

Figure 8 | Proportion mortality (%of total deaths), all ages, both sexes……………………………………….11

Figure 9 | Percentage of overweight and obesity in 1980 and 2013, with focus on Mozambique………………………………………………………………………………………………………………12

Figure 10 | Overweight and obesity in Mozambique in 1980 and 2012, by age groups………………………………………………………………………………………………………………13
Abbreviations

BMI – Body Mass Index
BP – Blood Pressure
CDs – Communicable Diseases
CVDs – Cardiovascular Diseases
MFCT - Mozambican Food Composition Table
NCDs – Noncommunicable Diseases
SD - Standard Deviation
WHO- World Health Organization
1. Background

1.1 Burden of noncommunicable diseases in Africa

Also known as infectious diseases, communicable diseases (CDs) can be passed, directly or indirectly, from one person to another and they are caused by pathogenic microorganisms such as bacteria, virus, parasites or fungi (WHO 2010). For centuries, CDs were the main cause of death in the entire world (Boutayeb and Boutayeb 2005). Nowadays, the number of deaths due to this type of diseases is low, with Africa being an exception (Figure 1).

![Figure 1](image_url)  
*Figure 1* | Percentage of total deaths due to communicable, maternal, neonatal and nutritional diseases in 1990 and 2014, by world region. Source: Institute for Health Metrics and Evaluation, University of Washington, 2016 (IHME 2016).
After Second Global War, life expectancy had increased due to medical progresses in terms of vaccination, antibiotics and better life conditions (Boutayeb and Boutayeb 2005). Besides this, globalization phenomenon was accompanied by a replacement of infectious diseases as the main cause of death by a gradual and continued rise of chronic and degenerative diseases (Belahsen 2014). As the name implies, noncommunicable diseases (NCDs), of long duration and slowly progression, cannot be passed from person to person (WHO 2015) and they cause major problems in industrialized countries. Despite of being known as “rich diseases” owing to doubtless association with better economic conditions, NCDs appeared spreading the entire world (Boutayeb and Boutayeb 2005) (Boutayeb 2005) (Figure 2).

Figure 2 | Percentage of total deaths due to non communicable diseases, in 1990 and 2014, by world region. Source: Institute for Health Metrics and Evaluation, University of Washington, 2016 (IHME 2016).
Translating to numbers, the number of deaths worldwide rose by near 8 million in 1990’s to 34.5 million in 2010, almost two-thirds of total deaths (Lozano, Naghavi et al. 2012). Surprisingly, approximately 80% of all deaths due to NCD occurred in the lowest income nations in 2008, discrepant from the 40% observed in 1990 (Murray and Lopez 1997).

Strengthening it, Boutayeb’s article help us getting elucidate about the evolution and projection of CDs and NCDs in developing countries, with NCDs achieving 80% of the global burden of disease (Boutayeb 2005).

Not hiding that there are still more deaths from infectious diseases in Africa, the burden of NCDs is increasingly rapidly and they are expected to become the most common causes of death in 2030. Besides Africa, the highest increase is expected in South-East Asia and the Eastern Mediterranean (WHO 2014).

The increasing burden of NCDs requires huge concern due to highly economic costs, and health service’s needs, especially in countries where premature death is devastating and effective and equitable health care services are difficult (Gomes, Damasceno et al. 2010, WHO 2015). In a joint report by the World Economic Forum and the Harvard School of Public Health, the economic burden of five NCDs (cardiovascular diseases (CVDs), cancer, chronic respiratory disease, diabetes and mental illness), will be responsible for a loss of US$ 47 trillion over the two decades (Bloom, Cafiero et al. 2011). So far, all member states of the United Nations have assumed a political declaration in which is expressed the need of an effort by the whole government and society to reduce risk factors as well as public health campaigns (United Nations 2011).
1.2 Nutritional, epidemiological and demographic transitions

Before demographic transition, life was short, births were many, growth was slow and the population was young. At 1980’s, at the beginning of transition, mortality decline and then fertility also decline, making population growth rates first to accelerate and then to slow again, moving toward low fertility, long life and old population. It had started at Europe and now it’s spread to all parts of the world, projected to be completed by 2100 due to truly association with socioeconomic development in terms of education, employment, rising incomes, improvements in health status, increased life expectancy and better life conditions, restructuring population dynamic (Lee 2003).

Globalisation is well linked to goods and cultures changes as well as food changes. Substantial increases in food consumption, changes in consumption patterns and modifications in the entire food system have occurred globally. The improvement in food production has led to a decrease of malnourished people in many developing regions in the world, even though a significant number still suffers from hunger and malnutrition (Schmidhuber and Shetty 2005). Besides the problem of insufficient protein and dietary intake, micronutrients deficiencies still exist in poor and middle countries, including Africa. The nutrition transition that is undergoing in these regions over the last two decades is a result of a more demographic, nutritional and epidemiological transition that attends development and urbanisation (Belahsen 2014). The rate of urbanization, which is defined as “positive when the urban population grows at a faster rate than the total population” (UNICEF 2012), is one of the most marked environmental and societal already felt and is increasing globally; from 33.6% of the world population living in urban areas in 1960 to 53.9% in 2015 (The World Bank 2016), and expected to achieve 61.1% in 2025 (Chockalingam and Camargo Maranhao 2003). Besides urbanization in developing countries has been faster than in developed ones, particularly in Africa and Asia regions that are projected to reach 56% and 64% urban at the middle of this century, the rate of urbanization with economic growth has been frailer than in developed countries and will still be less urbanized than other regions of the world (Figure 3). Rapid urbanization in low and middle countries reinforces the epidemiological transition in urban societies, which is altering the physical and social habitat of cities, leading to one of the most important global health issues of XXI century (Kroll, Bharucha et al. 2014).
The shift from traditional (e.g. undernutrition, unsafe water and sanitation) to modern (e.g. harmful use of alcohol, unhealthy diet, tobacco use, sedentary lifestyle) risk factors and frequent physiological changes (such as high blood pressure, high blood lipids, high fasting blood glucose and overweight/obesity) could explain why the entire world, including Africa’s, is facing the so-called epidemiological transition (WHO 2009), as shown in figure 4.

Figure 3 | Proportion urban by income groups, 1950–2050. Source: United Nations (UN 2014).
Moreover, the above mentioned risk factors contribute not only to the onset of cancer, but also of CVDs (Belahsen 2014). Cardiovascular diseases, a group of disorders of the heart and blood vessels, are the number one cause of death globally once there are more people dying from these than from any other cause. In the last two decades, the number of deaths from CVDs increased 31% and its estimated to increase from 15.6 million in 2010 to 28 million by 2030 (Lozano, Naghavi et al. 2012). According to World Health of Organization (WHO) global status report on NCDs 2014, 17.5 million people died from CVDs in 2012, which represents 31% of all global deaths. Moreover, about three quarters of CVDs deaths occurred in low and middle income countries (WHO 2014). Ischemic heart disease (13.3%) and stroke (11.1%) contributed for the major proportion of deaths. Hypertension, the largest single attributable risk factor to CV death, leads to 51% and 45% of deaths due to stroke and ischemic heart disease in 2004, respectively. The risk of dying from high blood pressure (BP) is doubly higher for low and middle income countries than for high income countries. (WHO 2009).
1.3 The Mozambique case

1.3.1 Mozambique country profile

Mozambique is a low income sub-Saharan country located in the south eastern Africa, distributed by eleven provinces (North: Niassa, Cabo Delgado and Nampula; Center: Zambézia, Tete, Sofala and Manica; and South: Maputo, Gaza, Inhambane). It already accounts with about 25 million inhabitants and according to Mozambican National Institute of Statistics population projections, is expected an increase of more than the double inhabitants in 2040 (46 181 058 inhabitants) when compared to 2007 (20 632 434 inhabitants) (Instituto Nacional de Estatística de Moçambique. 2007).

Before 1994, Mozambique was considered one of the poorest countries in the world due to civil war installed for almost two decades (after Portugal’s independence in 1975). After country’s first democratic election, some political stability had been established culminating in an impressive economic growth. However, this had not been followed by poverty’s and food security’s eradication as well as better life conditions such as the creation of jobs and livelihoods. Mozambique only ranked 178th out of 187 countries in the most recent Human Development Index and it’s expected for gross domestic product to continue decelerating until 2017 for about 6% (The World Bank 2016).

Despite the proportion of population living under poverty had decreased 15% between 1996/1997 (69%) and 2002/2003 (54%), the percentage of Mozambicans considered poor remained practically stable until 2008. This is explained by the stagnation growth in agriculture productivity and by the large increase of international food and fuel prices. This gets serious attention once almost 70% of Mozambicans lives in rural areas (poverty rate is higher than urban areas) and practically all of them are employed in this area (Arndt, Hussain et al. 2012). Despite this sector still remains unproductive, it is an important source of family’s income and the most important contributor for the national agricultural production. Data from the latest Household Budget Survey showed that families spend less money of their overall budget in food when compared to 2008/2009 (51% to 35,6%) (Insituto Nacional de Estatística 2016).

Talking about social progress index, Mozambique ranked 128th and 119th out of 135 countries in the access to safe water and sanitation, respectively. In 2008, 16% of all deaths in Mozambique were due to inadequate water, sanitation and hygiene practices (WHO 2008).
The high fertility rate (mean five children per woman) and high mortality rate (due to high under-five mortality (70 deaths per 1000 live births in 2015) and HIV/AIDS deaths) are depicted in the age-structured figure 5, also reflecting the poverty rate in this country.

![Population Pyramid from Mozambique, 2015](image)

**Figure 5** | Population pyramid from Mozambique, 2014.
Source: Central Intelligence Agency, 2015 (CIA 2015).

As expected, almost a half of population are aged below 15 years (45.13%) and only 6.35% over 55 years (CIA 2015). Far from the expectable, the coverage of antiretroviral therapy and the implementation of preventive measures to reduce childhood diseases and malaria (Joint United Nations Programme on HIV/AIDS 2010), made life expectancy increased from 42 years in 1997 to 53 years in 2015 (Instituto Nacional de Estatística e Ministério da Saúde 2012) (CIA 2015).
1.3.2 Non-communicable diseases in Mozambique

As in the other Sub-Saharan countries, the burden of NCDs, together with CDs prevails in this country (figure 6).

Figure 6 | Percentage of total deaths due to CDs, NCDs and injuries in 1980 and 2013, in Mozambique. Source: Institute for Health Metrics and Evaluation, University of Washington, 2016 (IHME 2016).
Although CDs are still in charge for the highest number of deaths and the largest burden of disease, NCDs accounted for 19.9% of total deaths in 2010, and they are increasing with age in Mozambican population, the same verified in developed countries (Figure 7) (IHME 2016).

![Figure 7](image)

**Figure 7** | Percentage of total deaths due to NCDs in 2013, by age group. Source: Institute for Health Metrics and Evaluation, University of Washington, 2016 (IHME 2016).

Data from the WHO latest report, Mozambique NCDs country profiles in 2014, showed us that NCDs already accounted for 23% of total deaths, and the huge slice is for CVDs (7%). (Figure 8).
CVDs were responsible for 5.6% of the deaths, cancer for 4.7%, chronic respiratory diseases for 1.4%, and diabetes for 0.9% (IHME 2016). As already verified in 1994 between Maputo inhabitants aged over 60 years (Dgedge, Novoa et al. 2001), cerebrovascular diseases were the main leading cause of death in 2010, causing one tenth of deaths in Mozambicans older than 69 years. Stroke hospitalization had one of the highest incidence in the developing settings, estimated to be 148.7 per 100,000, among 2005 and 2006 (Damasceno, Gomes et al. 2010).

Hypertension is a very important risk factor since it’s the large contributor for CVDs. In Mozambique, hypertension affects one-third of the population and CVDs already have an important public health impact (Damasceno, Azevedo et al. 2009) (Damasceno, Gomes et al. 2010). According to the literacy pattern, there were also urban and rural differences, with urban areas presenting a higher prevalence of hypertension. In contrast with body mass index and cholesterol, blood pressure is not correlated with economic factor (Damasceno, Azevedo et al. 2009). Despite the paradigm to major cause of death has been shifted from a predominance of nutritional deficiencies and infectious diseases to those classified as degenerative ones, this does not mean that different countries or even different regions within a country are at equal stages of the epidemiological transition (Amuna and Zotor 2008) (Yusuf, Reddy et al. 2001). There are noticeable differences when passing from a rural to an urban lifestyle, including dietary habits and physical activity patterns. Mozambicans presented a higher prevalence of overweight/obesity and had higher waist circumference, which is also observed in other African nations such as Democratic Republic of Congo, Madagascar.
or Algeria (Gomes, Damasceno et al. 2010). The prevalence of overweight and obesity has abruptly increased, from 13.2% in 1980 to 18.4% in 2010 (figure 9), and it’s equally reflected in all age groups (figure 10). Conversely the pattern observed in developed countries where higher education most likely means healthier lifestyles, this was not observed in Gomes et al study. Mozambicans with more literacy have higher prevalence of overweight and obesity when compared to individuals with less formal education, reflecting the early stages of transition (Gomes, Damasceno et al. 2010).

![Figure 9](image_url)  
Figure 9 | Prevalence of overweight and obesity in 1980 and 2013, with focus on Mozambique.  
Figure 10 | Overweight and obesity in Mozambique in 1980 and in 2012, by age groups. Source: Institute for Health Metrics and Evaluation, University of Washington, 2016 (IHME)
1.3.3 Hypertension and sodium in Mozambique

Sodium, the predominant ion of the extracellular fluid, regulates extracellular and plasma volume and is also important in neuromuscular function and maintenance of acid-base balance. It is readily absorbed from the intestine, carried to the kidneys to be filtered, and returned to the blood to maintain adequate levels. Usually, the amount of sodium absorbed is proportional to the intake in healthy adults once about 90% to 95% of normal body sodium loss is through the urine (the rest part is lost in feces and sweat) (Escott-Stump and Kathleen Mahan 2007).

Sodium excretion is maintained by a complex mechanism that involves glomerular filtration rate, the cells of the kidneys, the renin-angiotensin-aldosterone system, the sympathetic nervous system, catecholamines, and blood pressure. The sodium balance is regulated by aldosterone secreted by the adrenal cortex and when blood sodium levels rise, the thirst receptors stimulate the thirst sensation so that the ingestion of fluids returns sodium levels to normal (excrete more water and sodium in the urine) (Escott-Stump and Kathleen Mahan 2007).

Commonly, healthy kidneys are able to excrete excess sodium intake but there is a huge concern about persistent excessive sodium intake due to inevitable association to the development of hypertension (Escott-Stump and Kathleen Mahan 2007). The role of dietary sodium in BP is not fully understand but it is believed that this long-term regulation implicates sodium handling by the kidneys and is influenced by several factors (genetic, environmental, neurohormonal, nutritional and metabolic factors) (Jones 2004). Further attention should be given to this issue since less than 10% of Mozambican adults diagnosed with hypertension were under pharmacological treatment (Damasceno, Azevedo et al. 2009). Moreover, almost 64% never had their blood pressure measured (Damasceno, Padrao et al. 2013). Reasons for the increasing prevalence and poor hypertension controlled should be defined and approaches to prevent and improve control should be identified.

The strength of evidence for salt intake as a factor in BP is much stronger than other lifestyle factors (Tibazarwa and Damasceno 2014). High sodium intake was in charge for an estimated 3.1 million deaths worldwide in 2010, higher when compared to 2.2 million in 1990 (Lim, Vos et al.). Sodium reduction is one of the top 10 best measures for preventing NCDs and is likely to be cost-effective (Zarocostas 2011, Eyles, Shields et al. 2016). The WHO recommendations set no more than 2g of sodium (5 g of salt) in a day, so NCDs can be lowered (WHO 2012). Nonetheless, in all countries with recent data available, dietary sodium intake is well above the recommendations (WHO 2007).
Decreasing dietary salt intake from the current levels of 9-12 g/day to the recommended level of 5 g/day would have an important impact on reducing BP and so CVDs (Lim, Vos et al.).

A decline in the consumption of foods rich in vitamins, minerals and fibre, such as fruits, vegetables, legumes and whole grains, and an increment of processed foods, naturally energy dense and rich in sodium is expected with the globalization process. It is important to mention that the proportion of the population located in urban areas will continue to rise worldwide and it will be more noticeable and quickly in Asia and African continents than in the other regions (Popkin 2011).

So, regardless of being at the earliest stage of epidemiological transition (Gomes, Damasceno et al. 2010, Gomes, Damasceno et al. 2013), it’s expectable an increase of ultra-processed foods consumption, naturally high in sodium, reason why its ground to know not only the amount but also the main sources of dietary sodium. The most frequently ones tend to be ultra-processed foods and discretionary salt, and it is extremely variable due to the extent of urbanization/culture (Damasceno, Azevedo et al. 2009, Sookram, Munodawafa et al. 2015, Eyles, Shields et al. 2016).

The WHO set a target for countries to reduce population sodium intake by 30% toward 2000mg/d by 2025, with seventy-five countries responded to this (WHO 2013). Mozambique still not answered and there is no data about sodium intake in adult Mozambican using the gold standard method of 24hour urine collection (McLean 2014) that allows the assessment of distribution and average intake of sodium (Elliott; and Brown 2007).
2. Aims

This thesis aimed to deepen the knowledge about sodium contribution in the diet of the Mozambican adults.

In order to fulfil the main objective, the specific ones are to (1) identify the main dietary sources of sodium and to (2) estimate the urinary excretion of sodium ingested, in a 24-hour period within a sample of Maputo’s population.
3. Methods

Study design

For the present-community based cross sectional study, a convenience sample of one hundred Mozambican adults, aged 25 to 64 years and belonging to different households, was assembled between October 2012 and May 2013. A face-to-face interview using a structured questionnaire to collect information on demographic, socioeconomic and lifestyle characteristics (including sex, age, religion (5 missing values), education, partner status, job occupation (1 missing value), income (1 missing value), smoking habits, physical activity for leisure (1 missing value) or at work (2 missing values)), as well as anthropometric measurements and the assessment of 24-h recall and 24-hour urine collection. Exclusion criteria were pregnancy and physical or mental condition that impair the interview.

Demographic, socioeconomic and lifestyle characteristics

Social and demographic characteristics were assessed such as sex, age, religion (Christian, Mulism, other), predominant ancestry (African, Arabic, Indian, Chinese, white or mixed), marital status (married/currently living with someone or single/separated/widow and without life partner). School attained education were also asked and classified in five levels such as (1) less than 7 years (primary school not completed), (2) 7 years (primary school completed), (3) 8 to 11 years (secondary school not completed), (4) 12 years (secondary school completed) and (5) more than 12 years (Pos secondary school, professional course or higher education). Besides this classification, current job or the last job was also categorized into skilled/semiskilled non manual (teacher, nurse, director, clerk, supervisor shop, driver, policy, army staff and others), skilled or semiskilled manual (mechanic, carpenter, mason, other), unskilled manual (labourer, security, cleaner, other) or housekeeper (if never worked outside home).

Overall personal income per month (Metical) was asked, including allowances and other benefits, and stratified in (1) no income, (2) less than 3000, (3) 3000-5000, (4) 5000-8000, (5) 8000-15000 and (6) more than 8000.

To assess the smoking status, the participants were asked whether they currently smoked (one or more cigarettes per day), occasionally smoked or non-smokers. Finally, daily physical activity during labor time (sitting down most of the time, often standing/moving without having to lift/carry weights, or often standing/moving and often
carrying/lifting weights) or for leisure for at least 30 minutes (never or <1/week, 1/week on average, or 2-3 times/week on average) were also assessed. Smoking habits and physical activity were self-reported by participants.

24-hour urine collection

Participants were asked to provide a 24-hour urine collection. A container was supplied and they were carefully instructed (oral and written guidelines) to collect and complete 24-hour urine samples. They were taught to discard the first morning void and to collect all urine over the following 24-hour including the first void on the next morning, recording the start and finish collection in the questionnaire. Considering the participant’s comfort and for feasibility purposes, urine collections were held on Sundays and during the collection period, subjects were asked to store the collected urine in a cool place. Urine samples were sent to a certified laboratory in order to evaluate urinary creatinine (mg/day) (Jaffé reaction, Siemens Advia 1650) and urinary sodium (mEq/day) (indirect ion-selective electrodes methodology, Siemens Advia 1800) through analytical methods. Although sodium excretion has been reported in mEq/day, it was converted to mg/day through their molecular weight for comparative purposes (23mg Na=1mmol or 1 mEq Na). Sodium chloride excretion (commonly referred as salt) was conducted by multiplying the amount of sodium excreted by 2.55 factor (NaCl (g) = Na (g) x 2.55). For 24-hour urine collection validation, quality control has to be made through urinary creatinine excretion in relation to body weight according to age group (creatinine coefficient = creatinine [mg/day]/body weight [kg]). It was considered an acceptable indicator when the value was between 14.4 and 33.6 for males and between 10.8 and 25.2 for women (Liu, Ikeda et al. 2002). The failure of this criterion (n=19) resulted in the exclusion of individuals of the final data processing.

Dietary record

A 24-hour dietary recall referring to the day of the urine collection was made by a trained interviewer. Participants were asked to report all foods and beverages consumed during the previous 24 hours using a photographic book and household measures (spoons, plates, cups and glasses) to correctly quantify portion sizes. Not only the type and amount of added fat, sugar, salt and other seasonings, the brand of the processed food and the name of the dishes was reported, but also the details about the culinary method, amount consumed recipes and foods eaten outside home.

To convert food into nutrients, Food Processor Plus® (ESHA Research Inc., Salem, OR, USA) was used. Although this informatic program uses U.S. Department of
Agriculture food composition table, including raw and/or processed foods, it was added raw composition food from Mozambican Food Composition Table (MFCT) (Korkalo, Hauta-alus et al. 2011) and either Portuguese Food Composition Table (INSA 2007) and Brazilian Food Composition Table (Costa, Decca et al. 2011) for foods which composition was not available in MFCT. For commercialized and typically Mozambican foods, nutritional labels and scientific sources (Oliveira and Carvalho 1975, Kalenga Saka and Msomthi 1994, Lago, Gomes et al. 2006, Komane, Olivier et al. 2011, Alam, Mohanty et al. 2012) were taken into account, respectively.

The food codes used were categorized into 13 major groups (Marrero, He et al. 2014) namely (1) cereal and cereal products (wheat bread, whole grain bread, potato and sweet potato, rice, pasta, corn, manioc, cornflour and flour), (2) meat products (red meat, pig, poultry, goat and processed meat), (3) sugar, preservatives and confectionery (sugar, sugary products and condensed milk), (4) fish and seafood dishes (fish, dried shrimp and crab), (5) vegetables (vegetables and cassava leaves), (6) milk and dairy (milk, cheese, yogurt and powdered milk), (7) beverages (sugary drinks, tea and coffee), (8) fruits, (9) eggs, (10) Oils and fats (olive oil, oil, butter, margarine, cream), (11) fast-food, (12) soups, (13) other foods (oleaginous fruits and beans). The contribution of these 13 groups to sodium was calculated. An additional analysis was performed to evaluate the contribution of each food group to total sodium intake only in participants who ingested foods included in that food group.

Beyond this categorization, it was also used Monteiro et al criteria (Monteiro, Levy et al. 2010) so that foods can be classified by the extent and purpose of their processing such as (1) unprocessed/minimally processed foods, (2) processed ingredients and (3) ultra-processed food products.

Nutritional variables such as energy, carbohydrates, fat, protein, sodium and potassium were also analysed through WHO recommendations: 15-30% of total energy for fat (WHO 2003), 55-75% of total energy for carbohydrates (WHO 2003), 10-15% of total energy from protein (WHO 2003), <2000 mg/day of sodium (WHO 2012) and ≥3500 mg/day of potassium (WHO 2012).

**Anthropometry assessment**

For weight and height measurements was used a SECA® digital scale with an embedded stadiometer, with the subject lightly clothed, barefooted, positioned in the centre of the balance so that weight can be distributed over both feet and with the head positioned in the Frankfort plan, according to standard and validated procedures
Dietary sources of sodium and urinary sodium excretion in Maputo, Mozambique

(Stewart, Marfell-Jones et al. 2006). Weight and height were determined to the nearest 0.1 kilogram and 0.1 centimetres, respectively. BMI was calculated by Quetelet Index (Garrow and Webster 1985) as weight (kilograms) divided by square of height (metres) and WHO cutoffs for BMI were used to define underweight (<18.5 Kg/m²), normal weight (18.5–24.9 Kg/m²), overweight (25–29.9 Kg/m²) and obesity (≥30 Kg/m²) individuals (WHO 2000). Waist circumference was measured to the nearest 0.1 cm, using a constant tension tape, directly over the skin or over light clothing, at the level of the midpoint between the inferior margin of the last rib and the iliac crest in the mid-axillary-line. For analysis, participants were classified as having abdominal obesity as more than 88 cm and 102 cm for women and men respectively, according to the Third Report of the National Cholesterol Education Program Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Expert Panel on Detection, Evaluation and Treatment of High Blood Cholesterol in Adults 2001).

Statistical analysis

Data analysis was conducted using Statistical Package for Social Sciences (SPSS), version 23 with a 0.05 level of significance (p-value) and 95% confidence intervals considered. Descriptive and inferential statistical method were used. The Kolmogorov-Smirnov test was used to assess the assumption of normality. Independent Sample T-test or Mann Whitney U were performed to compare continuous variables and Chi-Square test was performed to compare categorical variables. Dietary sources of sodium were reported through thirteen food and beverages categories. A proportion to total food sodium or potassium was used to report results as mean percentage contribution of each category. Nutrients and food intake were also energy-adjusted according to residual method, and adjusted values were used to evaluate the differences between sexes.

Ethics

The study protocol was approved by the National Bioethics Commission for Health and written informed consent was obtained from all of the participants through the World Medical Association’s Declaration of Helsinki.
3. Paper

This dissertation includes the following publication that is going to be submitted to publication:


I was responsible for the definition of objectives, organization of data collection, as well as interpretation and discussion of the results. I actively participated in the elaboration of the final version of the article.
Urinary sodium and potassium excretion and dietary sources of sodium and in Maputo, Mozambique
Dietary sources of sodium and urinary sodium excretion in Maputo, Mozambique

Ana Queiroz¹, Albertino Damasceno²,³, Pedro Moreira¹,⁴,⁵, Célia Novela², Nuno Lunet³,⁴ Patricia Padrão¹,⁴

¹ Faculty of Nutrition and Food Sciences, University of Porto (FCNAUP), Porto, Portugal
² Faculty of Medicine, Eduardo Mondlane University, Maputo, Mozambique
³ Department of Clinical Epidemiology, Predictive Medicine and Public Health, Faculty of Medicine, University of Porto (FMUP), Porto, Portugal
⁴ EPIUnit – Epidemiology Research Unit, Institute of Public Health, University of Porto (ISPUP), Porto, Portugal
⁵ Research Centre in Physical Activity, Health and Leisure, Faculty of Sport, University of Porto (CIAFEL), Porto, Portugal

Correspondence:
Patrícia Padrão
Faculdade de Ciências da Nutrição e Alimentação da Universidade do Porto
Rua Roberto Frias, s/n
4200-465 Porto
Portugal
Telephone: +351 225074320
Fax: +351 225074329
E-mail: patriciapadrao@fcna.up.pt
ABSTRACT:

Objective: To evaluate the urinary excretion of sodium and potassium, and to estimate the main food sources of sodium intake in a sample of the Maputo inhabitants.

Design: A cross-sectional study using a convenience sample of one hundred Mozambican adults, belonging to different households, was assembled between October 2012 and May 2013. Sodium and potassium urinary excretion was assessed by a 24-h urine collection, and the coefficient of creatinine was used to validate completeness of urine collections. Food intake was assessed using a 24-h dietary recall and for the conversion to nutrients namely the sodium intrinsic in natural foods and sodium added to processed foods (non-discretionary sodium), the Food Processor software was used Salt added during culinary preparations (discretionary sodium) was estimated by the difference between urinary sodium excretion and non-discretionary sodium.

Setting: Maputo, Mozambique.

Subjects: one-hundred Maputo inhabitants aged 25 to 64 years (46 women and 54 men).

Results: Eighty-one participants with complete urine collection were included in the analysis. The mean urinary sodium excretion was 4575 (Standard deviation, 2055) mg/day in women and 3965 (Standard deviation, 1549) mg/day in men, and 95% of women and 91% of men did not meet the WHO recommendations for sodium. Discretionary sodium contributed 71.8% and 56.3% of total dietary sodium intake, in women and men respectively, followed by sodium from processed foods (19.9% in women and 30.9% in men) and sodium intrinsic in natural foods (8.3% in women and 12.8% in men).

The mean urinary potassium excretion was 1844 (Standard deviation, 761) mg/day in women and 1995 (Standard deviation, 775) mg/day in men, and 97% of women and 95% of men did not meet the WHO recommendations for potassium.

Conclusions: The great majority of the participants exceeded the recommended sodium intake and did not meet the recommendations for potassium intake. Discretionary sodium contributed with approximately two thirds to total sodium intake in this convenience sample of Maputo inhabitants.

KEY WORDS: sodium; salt; urinary sodium; urinary potassium; Mozambique; Africa
INTRODUCTION

High sodium intake increases blood pressure and negatively affects endothelial and cardiovascular function, being positively associated with kidney disease, and cardiovascular morbidity and mortality\(^1,2\).

The upper limit for sodium intake recommended by the World Health Organization (WHO) is two grams per day [equivalent to five grams of salt (sodium chloride)/day] \(^3\), although data on population sodium intake around the world show that the intake far exceeds the recommendations\(^4\). Despite the lack of data on sodium intake in Mozambique the knowledge on the topic is of major relevance, given the high prevalence of hypertension (25-64 years: 33.1% in 2005)\(^5\) and the increasing public health impact of cardiovascular diseases (CVD) in this setting. In addition, potassium is another key nutrient, inversely associated with blood pressure, and whose relation with sodium intake should be taken into account \(^6\) The WHO recommends a minimum potassium intake of 3510 mg/day and a sodium to potassium intake daily ratio of approximately one\(^7\).

In the last decades, a steep increase in urbanization has been observed in Mozambique\(^8\). Along with urbanization, the globalization process rises and promotes dietary changes. Most of the changes involves decreases in the consumption of foods rich in potassium such as legumes, fruits, vegetables, and a more frequent intake of processed foods frequently energy dense and rich in salt\(^9\). A previous study on culinary practices conducted with a sub-sample of the Maputo inhabitants of the present study, reported a large use of salt and chicken powdered stocks high in sodium\(^10\), the later reflecting the nutrition transition undergoing in Mozambique\(^11,12\).

It is expectable an increase of ultra-processed foods consumption, and consequently a rise in sodium intake. In addition to industrial foods, added salt in culinary preparations appears to be one of the most important contributors to the overall sodium intake in some populations, although the sources of sodium differ across countries and cultural settings \(^5,13,14\).

The WHO set a target for countries to reduce population sodium intake by 30% toward 2000mg/d by 2025\(^15\), being essential the monitoring of sodium intake, and not less important the sodium to potassium ratio, across settings.

We aimed to (i) evaluate the urinary excretion of sodium, potassium and sodium to potassium ratio; and (ii) to estimate the contribution of discretionary (sodium from salt
added during culinary preparations) and non-discretionary sodium (sodium intrinsic in natural foods and sodium added to processed foods) to total sodium intake in a sample of the Maputo inhabitants. We aimed to (i) evaluate the urinary excretion of sodium; (ii) to estimate the main food sources of sodium and (iii) to quantify the contribution of processed/ultra-processed for total sodium intake in a sample of the Maputo inhabitants.
METHODS

Study Design

For the present-community based cross sectional study, a convenience sample of one hundred Mozambican adults, aged 25 to 62 years and belonging to different households, was assembled between October 2012 and May 2013. A face-to-face interview using a structure questionnaires was conducted to collect information on demographic characteristics including sex, age, and education. Anthropometric measurements, a 24-h recall, and 24-hour urine were also collected.

24 hour urine collection

Participants were asked to complete a 24-hour urine collection. A container was supplied and they were carefully instructed (oral and written guidelines) to collect and complete a 24-hour urine sample. They were taught to discard the first morning void and to collect all urine over the following 24-hour including the first void on the following morning, and the time of the start and finish collection was recorded in a questionnaire. Urine samples were analyzed for urinary creatinine (mg/day) (Jaffé reaction, Siemens Advia 1650), urinary sodium (mEq/day) (indirect ion-selective electrodes methodology, Siemens Advia 1800) through analytical methods. Although sodium excretion has been reported in mEq/day, it was converted to mg/day through their molecular weight for comparative purposes.

For 24-hour urine collection validation, quality control was performed through urinary creatinine excretion in relation to body weight according to age group\(^{16}\). Values between 14.4 and 33.6 for men and between 10.8 and 25.2 for women, were considered acceptable. The failure of this criterion (n=19) resulted in the exclusion of individuals of the final data analyses. Thus, the final sample consisted of 81 Mozambican adults (43 men) with valid urine collection.
Dietary intake

A 24-hour dietary recall referring to the day of urine collection was conducted by a trained interviewer. Participants were asked to report all foods and beverages consumed during the previous 24 hours using a photographic book and household measures (spoons, plates, cups and glasses) to quantify portion sizes. Not only type and amount of added fat, sugar, salt and other seasonings, the brand of processed food and the name of the dishes was reported, but also the details about the culinary method, recipes, amount consumed as well as foods eaten outside home. To convert food into nutrients, Food Processor Plus® was used. Although this software uses U.S. Department of Agriculture food composition table, including raw and/or processed foods, it was added the raw composition food from Mozambican Food Composition Table (MFCT) and from the Brazilian Food Composition Table for foods which composition was not available in MFCT. For industrial food products, nutritional labels were used. The sodium intrinsic in natural foods and sodium added to processed foods (non-discretionary sodium), was then calculated and the salt added during culinary preparations (discretionary sodium) was estimated by the difference between urinary sodium excretion and non-discretionary sodium.

Anthropometric measures

For weight and height measurements a SECA® digital scale with and embedded stadiometer was used, with the subject lightly clothed, barefooted, positioned in the centre of the scale and with the head positioned in the Frankfort plan, according to standard procedures. Weight and height were determined to the nearest 0.1 kilogram and 0.1 centimetres, respectively. Body mass index (BMI) was calculated by Quetelet Index as the weight (kilograms) divided by square of height (metres) and WHO cutoffs were used to define underweight (<18.5 Kg/m²), normal weight (18.5-24.9 Kg/m²), overweight (25.0-29.9 Kg/m²) and obesity (≥30 Kg/m²) individuals(17). Waist circumference was measured to the nearest 0.1 cm, using a constant tension tape, directly over the skin at the level of the midpoint between the inferior margin of the last rib and the iliac crest in the mid-axillary-line. For analysis, participants were classified as having abdominal obesity as higher than 88 cm and 102 cm for women and men respectively(18).
Statistical analysis

Data analysis was conducted using Statistical Package for Social Sciences (SPSS), version 23 with a 0.05 level of significance (p-value) and 95% confidence intervals considered. Independent Sample T-test and Mann–Whitney U test were performed to compare continuous variables and Chi-Square test was used to compare categorical variables. The final sample consisted of 81 Mozambicans with valid urine.

Ethics

The study protocol was approved by the National Bioethics Commission for Health and written informed consent was obtained from all of the participants through the World Medical Association’s Declaration of Helsinki.
RESULTS

Participants were on average 40 years old and approximately half of the sample reported up to seven schooling years (completed primary school). More than a half of the participants were classified as overweight and obese (Table I).

The most frequently consumed food groups in the previous 24 hours were cereal and cereal products (100%), oils and fats (96%) and vegetables (89%), with a median intake of 396g (Standard deviation, 215g), 12g (Standard deviation 14g), 92g (Standard deviation 72g), respectively. 25% of the sample met the recommended intake of 400 g of fruit and vegetables.

From dietary records, mean non-discretionary sodium intake was 1291 mg/d in women and 1731 mg/d in men (p=0.048).

Results from urine collection are shown in Table II. The mean urinary sodium excretion was 4575 (Standard deviation, 2055) mg/day in women and 3965 (Standard deviation, 1549) mg/day in men, and 95% of women and 91% of men did not meet the WHO recommendations for sodium. The mean urinary potassium excretion was 1844 (Standard deviation, 761) mg/day in women and 1995 (Standard deviation, 775) mg/day in men, and 97% of women and 95% of men did not meet the WHO recommendations for potassium.

Mean urinary sodium/potassium ratio was 2.8 (Standard deviation, 1.5) for women and 2.2 (Standard deviation, 1.3) for men.

Overall, sodium from salt added during culinary preparations was the largest contributor to total sodium intake (71.8% in women and 56.3%), followed by salt from processed foods (19.9% in women and 30.9% in men) and sodium intrinsic in food (8.3% in women and 12.8% in men) (Figure 1).
DISCUSSION

To the best of our knowledge, this is the first study on sodium intake in a Mozambican population, using 24-hour urinary sodium excretion. Our results have shown that 93% of participants exceeded the recommended sodium intake, being the mean intake more than the double endorsed by the WHO\(^3\). Sodium from salt added in culinary preparations contributed with almost two thirds to total sodium intake in this setting.

Although data on sodium excretion in sub-Saharan countries are scarce, a recently published systematic review and meta-regression analyses reported that in some adult populations such as South Africa, Tanzania and Ghana, sodium intake was above 2 g, in accordance with the present study. It has been reported that populations from sub-Saharan African countries are more vulnerable to the effects of a high sodium diet than other populations due to genetic factors and the greater prevalence of inter-uterine growth restriction\(^{19}\). However, it has been documented that a reduction in sodium intake of 100 mmol/d contributes to a 2.3 mmHg reduction in BP\(^{20}\) which is expected to decrease stroke mortality, ischemic heart disease and other vascular diseases\(^{13}\).

No significant differences between sexes were observed regarding sodium excretion, in this study in accordance to what has been described in other sub-Saharan African countries\(^{19}\). However, in a worldwide systematic review mean sodium intake was always lower in women, the difference between sexes ranging from 8.9% in South Asia to 10.7% in Western Europe\(^{21}\). In the latter study, estimated sodium intakes ranged from 2.18 g/day in Eastern Sub-Saharan Africa to 4.80g/day in Asian regions\(^{21}\).

Discretionary salt was the leading main source of sodium intake in accordance with other studies conducted in different countries\(^{14, 22}\) including South Africa\(^{23}\), Japan and China\(^{24, 25}\). On the contrary, in European and North American countries sodium intake is dominated by sodium added by industry in processed/ultra-processed foods\(^{26}\). Even though discretionary salt was the main source of sodium in this study, it is expectable an increase in the consumption of ultra-processed foods\(^{27}\) along with globalization.

In addition to high sodium intake, a low intake of potassium, which is inversely related to blood pressure and to the risk of stroke \(^{28}\) was also observed. Our data on urinary potassium excretion was well below the minimum value recommended by the WHO. Diets high in processed foods, which reduces the natural amount of potassium in
many food products, and low in fresh fruits and vegetables contribute to lower values of potassium intake\(^{29}\).

The ratio between sodium and potassium daily intake can easily assess dietary changes over time and identify populations at high risk for nutrition-related chronic disease, once an elevated sodium/potassium ratio is associated with higher blood pressure\(^{30}\) and increased risk of CVD\(^{31}\). In our study, mean sodium/potassium ratio was above the WHO recommendations that suggest a ratio of approximately one to one, which is considered beneficial for health \(^{28}\). Our results are consistent with the ones recently published about sodium and potassium intake in South Africa: 77% consumes more than 5g salt/day, 93% of the population did not meet the potassium recommendations and median sodium to potassium ratio was 3.5 (even higher than our median ratio)\(^{32}\). This result reinforces the need to decrease the intake of sodium and increase potassium in Mozambique.

The 24-hour urine collection, the major strength of our study, is considered to be the clinical gold standard to assess sodium intake\(^{22, 33-36}\) since 90% of ingested sodium is excreted in the urine\(^{36}\). Besides rigorous validation through urinary creatinine excretion, which shrunk bias stemming from under or over collection, more than a single 24-hour urine collection should have been obtained from each participant to decreased daily variability.

Sodium reduction is considered to be cost effective and one of the top 10 “best buys” interventions for preventing non-communicable diseases (NCDs) \(^{13, 20}\). It is also important to note that the effects of sodium reduction on blood pressure tend to be greater in blacks, and in hypertensive subjects, which would be of great importance in Mozambique given the high proportion of hypertensive subjects not controlled\(^{37}\).

In the WHO Global Action Plan for the Prevention and Control of Non-Communicable Diseases 2013-2020, one of the key target is to make a 30% relative reduction of sodium intake\(^{15}\). In Sub-Saharan countries under epidemiological and nutritional transitions it gets further relevance since it is expected an increase of globalization which is frequently associated with dietary changes including the increase of sodium rich and potassium poor foods.
Preventative strategies focused on salt reduction become the best approaches \(^{(19)}\).

In a very recent systematic review about salt reduction initiatives around the world is shown that Eastern Mediterranean, South-East Asia and Africa are the three regions with the least salt reduction activity and where the NCDs are projected to increased most \(^{(38)}\).

Implementing a salt reduction programme such as the successful one in the United Kingdom (15\% reduction in the average salt intake) and already followed by other countries namely United States, Canada and Australia, would be a great step \(^{(39)}\). The emerge interventions on salt intake reduction in the sub-Saharan Africa region were applied in South Africa (through legislation to make the food industry reduce the salt content of selected products) and in Mauritius (through salt reduction in bread) \(^{(14)}\).

Setting targets for population salt intake and developing a salt reduction strategy involving different stakeholders namely the government and the food industries, may contribute to decrease sodium intake in Mozambique. Measures to regulate the sodium content in processed foods, along with campaigns to rise the population awareness on healthy eating, anticipating an expected shift towards a more “industrialized” food pattern may be beneficial. Strategies to improve fruit and vegetable consumption would thus increase potassium intake as well as other beneficial health effects.
CONCLUSION

The majority of the participants far exceeded the recommended sodium intake and did not meet the recommendations for potassium intake. Sodium from salt added to culinary preparations contributed with almost two thirds to total sodium intake in this convenience sample of Maputo inhabitants. Implementing strategies to decrease sodium and increase potassium intake should be implemented in order to prevent NCDs in Mozambique.
REFERENCES


Table I - Sample characteristics of the study sample (25-62 years) (n=81).

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Women (n=41)</th>
<th>Men (n=41)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>School attained education (n) ¹</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary school not completed</td>
<td>11</td>
<td>5</td>
<td>&lt;0.144</td>
</tr>
<tr>
<td>Primary school completed</td>
<td>12</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Secondary school not completed</td>
<td>5</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Secondary school completed</td>
<td>9</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Post secondary school</td>
<td>1</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Weight (kg) ²</td>
<td>77.8 (16.0)</td>
<td>70.7 (12.1)</td>
<td>0.025</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.6 (0.1)</td>
<td>1.7 (0.1)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Table II - Urinary data on sodium and potassium excretion by sex (25-62 years)

<table>
<thead>
<tr>
<th>Women n=38</th>
<th>Men n=43</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium (mg/day) ³</td>
<td>4573 (2055)</td>
<td>3965 (1549)</td>
</tr>
<tr>
<td>Salt (g/day) ⁴</td>
<td>11.0 (5.1)</td>
<td>9.9 (3.9)</td>
</tr>
<tr>
<td>% of compliance with recommendations ⁴</td>
<td>95%</td>
<td>91%</td>
</tr>
<tr>
<td>Potassium (mg/day) ⁵</td>
<td>1844 (761)</td>
<td>1995 (775)</td>
</tr>
<tr>
<td>% of compliance with recommendations ⁵</td>
<td>97%</td>
<td>95%</td>
</tr>
<tr>
<td>Ratio Na⁺/K⁺</td>
<td>2.8 (1.5)</td>
<td>2.2 (1.3)</td>
</tr>
</tbody>
</table>

¹ Values are mean (standard deviation)  
² Between-sex analysis by Mann-Whitney Test  
³ Analysis of y² for categorical variables  
⁴ Analysis by Student t test for continuous variables  
⁵ Analysis by χ² for categorical variables

---

### Dietary Sources of Sodium and Urinary Sodium Excretion in Maputo, Mozambique

#### Dietary Intake

<table>
<thead>
<tr>
<th>Dietary source</th>
<th>n</th>
<th>Median (minimum, maximum)</th>
<th>Median (minimum, maximum)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereal and cereal products (g/d)</td>
<td>81</td>
<td>352 (103, 1081)</td>
<td>366 (63, 1507)</td>
<td>0.298</td>
</tr>
<tr>
<td>Wheat bread (g/d)</td>
<td>65</td>
<td>150 (0, 600)</td>
<td>150 (0, 700)</td>
<td>0.283</td>
</tr>
<tr>
<td>Rice (g/d)</td>
<td>70</td>
<td>107 (0, 253)</td>
<td>107 (0, 320)</td>
<td>0.344</td>
</tr>
<tr>
<td>Meat products (g/d) ⁶</td>
<td>51</td>
<td>47 (0, 500)</td>
<td>63 (0, 300)</td>
<td>0.425</td>
</tr>
<tr>
<td>Milk and milk products (g/d) ⁶</td>
<td>24</td>
<td>0 (0, 420)</td>
<td>0 (0, 430)</td>
<td>0.998</td>
</tr>
<tr>
<td>Sugars, preserves and confectionery (g/d) ⁷</td>
<td>68</td>
<td>23 (0, 332)</td>
<td>12 (0, 250)</td>
<td>0.403</td>
</tr>
<tr>
<td>Fish and seafood dishes (g/d) ⁷</td>
<td>35</td>
<td>0 (0, 312.5)</td>
<td>0 (0, 375)</td>
<td>0.805</td>
</tr>
<tr>
<td>Vegetables (g/d) ⁷</td>
<td>72</td>
<td>63 (0, 249)</td>
<td>94 (0, 344)</td>
<td>0.309</td>
</tr>
<tr>
<td>Beverages (g/d)</td>
<td>68</td>
<td>560 (0, 1300)</td>
<td>420 (0, 2360)</td>
<td>0.293</td>
</tr>
<tr>
<td>Fruits (g/d)</td>
<td>48</td>
<td>125 (0, 1125)</td>
<td>83 (0, 1016)</td>
<td>0.468</td>
</tr>
<tr>
<td>Eggs (g/d)</td>
<td>28</td>
<td>0 (0, 110.0)</td>
<td>0 (0, 110)</td>
<td>0.077</td>
</tr>
<tr>
<td>Oils and fats (g/d) ⁸</td>
<td>78</td>
<td>7 (0, 32)</td>
<td>9 (0, 105)</td>
<td>0.200</td>
</tr>
<tr>
<td>Oil (g/d)</td>
<td>72</td>
<td>4.5 (0, 31.6)</td>
<td>7.91 (0, 57.9)</td>
<td>0.150</td>
</tr>
<tr>
<td>Fast food (g/d)</td>
<td>2</td>
<td>0 (0, 360)</td>
<td>8 (0, 58)</td>
<td>0.916</td>
</tr>
<tr>
<td>Soups (g/d)</td>
<td>2</td>
<td>0 (0, 19)</td>
<td>0 (0, 17)</td>
<td>0.916</td>
</tr>
<tr>
<td>Other foods (g/d)</td>
<td>60</td>
<td>68 (0, 199)</td>
<td>94 (0, 318)</td>
<td>0.200</td>
</tr>
<tr>
<td>Peanut (g/d)</td>
<td>38</td>
<td>17 (0, 203)</td>
<td>0 (0, 169)</td>
<td>0.661</td>
</tr>
</tbody>
</table>

⁶ Analysis by χ² for categorical variables  
⁷ Analysis by Student t test for continuous variables

---

### Urinary Data on Sodium and Potassium Excretion by Sex

<table>
<thead>
<tr>
<th>Women n=38</th>
<th>Men n=43</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium (mg/day) ³</td>
<td>4573 (2055)</td>
<td>3965 (1549)</td>
</tr>
<tr>
<td>Salt (g/day) ⁴</td>
<td>11.0 (5.1)</td>
<td>9.9 (3.9)</td>
</tr>
<tr>
<td>% of compliance with recommendations ⁴</td>
<td>95%</td>
<td>91%</td>
</tr>
<tr>
<td>Potassium (mg/day) ⁵</td>
<td>1844 (761)</td>
<td>1995 (775)</td>
</tr>
<tr>
<td>% of compliance with recommendations ⁵</td>
<td>97%</td>
<td>95%</td>
</tr>
<tr>
<td>Ratio Na⁺/K⁺</td>
<td>2.8 (1.5)</td>
<td>2.2 (1.3)</td>
</tr>
</tbody>
</table>

⁵ Analysis by Student t test for continuous variables.
**Figure 1** – Sodium contribute (%) from discretionary salt use (1), salt added during processing (2) and sodium intrinsic in food (3) for women (A) and men (B) respectively.
4. Conclusions

This thesis shows that sodium intake in this sample of Maputo inhabitants far exceeds the recommendations.

Besides discretionary salt has been the main leading source of sodium, in the future, it’s expectable a greater contribution from sodium though processed foods. Mozambique is considered to be in the early stage of the nutrition transition due to gradual differences saw through unprocessed/minimally processed foods and traditional dishes to ultraprocessed food products intake.

In addition to sodium, it was also shown the need to increase potassium intake by promoting the intake of fruit and vegetables. The Na⁺/K⁺ ratio, considered a stronger risk factor for hypertension than each of these nutrients alone, tend to be above the recommendations (>1.0) in “western” diets and it was also observed in this sample of Mozambique, reinforcing the epidemiological transition undergoing this country.

The economic and social development of the country, along with the increasing urban context of Maputo, are driving the changes in dietary patterns. To prevent the expected growth of NCDS due to a more industrialized food pattern, close monitoring should be considered in order to anticipate the negative effects of globalization. Preventive strategies must include consumer education in order to prevent the added salt during food preparation. A partnership between the government, retailers and manufacturers could also be a positive step towards the reformulation of processed foods so sodium content could be decreased. To assure acceptability of the reduced sodium content in processed foods, technical strategies need to be studied. Public campaigns are also needed to get population awareness about healthy eating.

The main conclusion of this thesis are the following:

- Mean sodium intake was more than the double endorsed by WHO recommendations;
- The majority of the individuals did not meet the recommendations for potassium intake;
- The ratio Na⁺/K⁺ was above the recommendations, suggesting dietary changes well related to higher BP;
- Sodium added from salt added in culinary preparations contributed with almost two thirds of total sodium intake in this setting;
- It’s necessary to develop a salt reduction strategy.
5. References


IOM (2004). Dietary Reference Intakes For Water, Potassium, Sodium, Chloride, and Sulfate. THE NATIONAL ACADEMIES PRESS

Washington, D.C., Institute of Medicine of The National Academies.


Dietary sources of sodium and urinary sodium excretion in Maputo, Mozambique


