Towards Population Salt Reduction to Control High Blood Pressure in Ghana: Using epidemiological data for Policy Direction

by

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Month/year
Executive Summary

A large body of evidence has shown that excess salt intake is associated with hypertension and nutrition related non-communicable diseases (NCDs). Global salt intake is high with populations consuming as much as twice the World Health Organization (WHO)’s recommended intake of 5g/day. Low- and middle-income countries (LMICs) are disproportionately affected due to the nutrition transition taking place in those countries that is associated with an influx of highly processed foods that are becoming more affordable, and accompanied by changing lifestyles and changing dietary preferences. This has increased the availability and intake of energy dense nutrient poor (EDNP) foods that are particularly high in salt in LMICs.

This thesis outlines six studies that sought to provide a systematic approach towards finding evidence, building advocacy and developing strategies to curb excess salt intake and rising hypertension in Ghana. Data used in studies that comprise the thesis were collected in the WHO’s Study on global AGEing and adult health (WHO-SAGE); a multi-country longitudinal study conducted in six LMICs namely China, Ghana, India, Mexico, Russia and South Africa (SA). Within each country, the WHO-SAGE study has recruited a nationally representative sample of predominantly 50+ year old participants. In the two WHO-SAGE countries from the African continent, namely Ghana and SA, a nested sub sample was additionally selected in Wave 3 to provided 24hr urine samples for the analysis of sodium (Na), potassium (K), creatinine (Cr) and iodine (WHO-SAGE Salt and Tobacco study). This thesis is largely based on data from the salt sub-study, and the PhD candidate was heavily involved in the planning and data collection for the Ghana sub-study. This thesis reports analyses from WHO-SAGE datasets from Ghana for Waves (W) 1 (2007/8), 2 (2015) and 3 (2019) and makes comparisons with corresponding WHO-SAGE data from South Africa Waves, where appropriate.
In order to understand the context of the food environment in terms of food intake, it was important to identify food sources in LMICs that contribute most to dietary salt consumption. A systematic literature review was conducted to evaluate the dietary sources of salt in LMICs (Study 1). The review identified that breads, meat and meat products, bakery products, instant noodles, salted preserved foods, milk and dairy products, and condiments were major sources of salt in LMICs. The data summarized in this review is useful to inform development of health and consumer education programmes and policy directives related to reduction in the production and consumption of such foods, provide evidence to advocate for reformulation of these foods to be lower in salt, and identification of alternative food sources.

In addressing population salt reduction, identification of consumer knowledge, attitudes and behaviours (KAB) are critical to influence food literacy and identify interventions required to drive food behaviour change. We examined the KAB of the Ghanaian main survey sample in WHO-SAGE W2 and compared the data with that of the W2 South African sample (Study 2). Comparison between the two countries is of interest because South Africa has a long history of nutrition education related to its Food Based Dietary Guidelines that encourage reduction of salt added to foods (discretionary salt) and avoidance of salty foods, as well as mass media campaigns targeting improved awareness of the association between salt and raised blood pressure - while Ghana does not. Ghana has only focused on the iodine-related message that iodised salt helps prevent iodine deficiency disorders. South Africans were more likely than Ghanaians to add salt to food at the table (OR 4.80, CI 4.071–5.611, p < 0.001) but less likely to add salt to food during cooking (OR 0.16, CI 0.130–0.197, p < 0.001). Surprisingly, despite greater exposure to consumer education strategies on salt reduction, South Africans were less likely to take action to control their salt intake (OR 0.436, CI 0.379–0.488, p < 0.001). The findings emphasized a need to intensify consumer awareness on discretionary salt use and behaviour modification in both countries.
An important component of this thesis was the quantification of population salt intake in Ghana, using the gold standard methodology of 24hr urinary sodium measurements, and its association with blood pressure (BP) (Study 3). BP was measured in triplicate and 24hr urinary Na, K and Cr levels were determined. Median salt intake was 8.3g/day (IQR 7.5) and approximately two-thirds of participants had potassium intakes below the WHO recommended level of 90mmol/day. Despite a lack of association between salt and BP, Na: K ratios above 2mmol/mmol were positively associated with the slope of increasing BP with age. This study highlights an urgent need for salt reduction policy in Ghana, that is accompanied by strategies to increase dietary K intake.

A follow-up study (Study 4) was conducted in participants who were 50+ years old at baseline in the WHO-SAGE Ghana W1 survey (data collected in 2007/9) and who participated in the WHO-SAGE Ghana W3 survey (data collected in 2019). Assessment of BP change over time showed that diastolic BP decreased by 9.7mm Hg and pulse pressure (PP) increased by 9.5mm Hg. Hypertension prevalence remained consistently high (W1: 52.0%, CI = 0.48-0.55; W3: 48.8%, CI = 0.45-0.52) in the cohort. Hypertension awareness increased by 37% with no differences among hypertensives who were on antihypertensive medications nor those that were both on antihypertensive medications and had controlled BP. Reduction in DBP was associated with increasing age, living in rural areas and having health insurance while increased awareness of hypertension was associated with residing in urban areas, having health insurance and increasing body mass index (BMI). The data highlights the need to intensify the treatment of hypertension.

Universal iodization of salt and its compatibility salt reduction has been widely discussed in contemporary public health research. A comparative study assessed urinary iodine excretion (UIE) among a sample of adults from Ghana and SA – both countries with national salt iodization programmes but only one (SA) that has implemented mandatory salt legislation (Study 5). Comparing data from the salt sub study in W3 in both countries, associations between salt and iodine intakes could be assessed. In Ghana, median Na
excretion was equivalent to a salt intake of 10.1g/day (IQR 7.6) while median UIE was 182.4 µg/l (IQR 162.5), with a weak correlation ($r = 0.1501, p < 0.0011$) between salt intake and UIE. In SA, salt and iodine values were both lower (median salt = 5.6g/day (IQR 5.0) and median UIE = 100.2 µg/l (IQR 129.6) with a moderate positive association ($r = 0.4050, p < 0.0001$) between salt intake and UIE.

An important part of the thesis was to disseminate and translate the novel findings for uptake by policy makers in Ghana. As well, as conventional outputs such as publications in international, peer reviewed journals, participatory action research (Study 6) was undertaken to discuss the evidence from this thesis and develop a road map for advocacy and support for salt reduction interventions in Ghana. To achieve this objective a stakeholder meeting involving representatives from government agencies, academia, Non-Governmental Organizations (NGOs), Civil Society Organizations (CSOs) and international partners was organized in Ghana in February 2019. The conference reached a consensus with recommendations that are being considered for inclusion in the revision of Ghana’s national NCD policy.

Overall, this thesis provided a synthesis of the literature and has conducted original research to provide a basis for action for salt reduction interventions in Ghana. It has identified that a multisectoral approach is essential to address discretionary salt use and the high intake of salt from other food sources and that there is a need to intensify efforts in the prevention and management hypertension.
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Finally, I would like to thank my family and friends who have been with me in this journey for their prayers, support and encouragement. Special thanks to my wife, Banat for her love and devotion to this course. She cried more than me, when the challenges were at their peak. Many thanks to Paul Moretti and the entire Moretti family, and Awaken Church, Wollongong for their love and encouragement and prayers.
Certification

I, Elias Kwashievi Menyanu, declare that this thesis, submitted in fulfilment of the requirements for the award Doctor of Philosophy, in the School of Medicine, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. This document has not been submitted for qualifications at any other academic institution.

Elias Kwashievi Menyanu
Date:31/10/2020
Dedication

To the late Prof. Joseph Kwesi Ogah for his undaunted love and mentorship which has spurred me on till today.
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<th>Description</th>
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<td>AAS</td>
<td>Atomic Absorption Spectrophotometry</td>
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<td>ABP</td>
<td>Ambulatory Blood Pressure</td>
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<td>ACLS</td>
<td>Aerobics Center Longitudinal Study</td>
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<td>AHT</td>
<td>Antihypertensive Medication</td>
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<tr>
<td>BSR</td>
<td>Behavioral and Social Research</td>
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<tr>
<td>BMI</td>
<td>Body Mass Index</td>
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<td>BP</td>
<td>Blood Pressure</td>
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<tr>
<td>CAD</td>
<td>Coronary Artery Disease</td>
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<tr>
<td>CAPI</td>
<td>Computer Assisted Personal Interview</td>
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<tr>
<td>CARDIA</td>
<td>Coronary Artery Risk Development in Young Adults</td>
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<tr>
<td>CCD</td>
<td>Cortical Collecting Duct</td>
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<tr>
<td>CDC</td>
<td>Centers for Disease Control</td>
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<tr>
<td>CEGIS</td>
<td>Center for Environment and Geographic Information System</td>
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<tr>
<td>CI</td>
<td>Confidence Interval</td>
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<tr>
<td>CoEHD</td>
<td>Centre of Excellence in Human Development</td>
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<tr>
<td>COMBI</td>
<td>Communication for Behavioural Impact</td>
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<tr>
<td>CSOs</td>
<td>Civil Society Organizations</td>
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<td>Cr</td>
<td>Creatinine</td>
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<td>CVD</td>
<td>Cardiovascular Disease</td>
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<td>DASH</td>
<td>Dietary Approaches to Stop Hypertension</td>
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<td>DBP</td>
<td>Diastolic Blood Pressure</td>
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<tr>
<td>DCT</td>
<td>Distal Convoluted Tubule</td>
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<tr>
<td>EAR</td>
<td>Estimated Average Requirement</td>
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<td>EAs</td>
<td>Enumeration Areas</td>
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<td>Abbreviation</td>
<td>Full Form</td>
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<td>EDNP</td>
<td>Energy Dense Nutrient Poor</td>
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<td>ENaC</td>
<td>Epithelial Na+ Channel</td>
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<tr>
<td>ESC</td>
<td>European Society of Cardiology</td>
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<td>ESH</td>
<td>European Society of Hypertension</td>
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<td>FDA</td>
<td>Food and Drugs Authority of Ghana</td>
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<td>FFQ</td>
<td>Food Frequency Questionnaire</td>
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<td>GCC WHS+</td>
<td>World Health Survey Plus, Arabian Gulf Coast Cooperation Council</td>
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<td>GDP</td>
<td>Gross Domestic Product</td>
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<td>GHS</td>
<td>Ghana Health Service</td>
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<td>GIS</td>
<td>Ghana Iodine Survey</td>
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<td>GIS</td>
<td>Geographical Information System</td>
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<tr>
<td>GNI</td>
<td>Gross National Income</td>
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<td>ID</td>
<td>Iodine deficiency</td>
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<td>IDD</td>
<td>Iodine Deficiency Disorders</td>
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<tr>
<td>INDEPTH</td>
<td>International Network of field sites with continuous Demographic Evaluation of Populations and Their Health in developing countries</td>
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<tr>
<td>HF</td>
<td>Heart Failure</td>
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<tr>
<td>INTERSALT</td>
<td>International Study of Sodium, Potassium, and Blood Pressure</td>
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<td>INTERMAP</td>
<td>International Population Study on Macronutrients and Blood Pressure</td>
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<td>IPAQ</td>
<td>International Physical Activity Questionnaire</td>
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<tr>
<td>IQ</td>
<td>Intelligent Quotient</td>
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<td>IQR</td>
<td>Inter Quartile Range</td>
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<td>JHW</td>
<td>Jaipur Heart Watch</td>
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<td>HIC</td>
<td>High Income Countries</td>
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<tr>
<td>Abbreviation</td>
<td>Definition</td>
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<tr>
<td>K</td>
<td>Potassium</td>
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<tr>
<td>KAB</td>
<td>Knowledge, Attitudes and Behaviours</td>
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<td>LMICs</td>
<td>Low- and Middle-Income Countries</td>
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<tr>
<td>MAP</td>
<td>Mean Arterial Pressure</td>
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<tr>
<td>METS</td>
<td>Metabolic Equivalents</td>
</tr>
<tr>
<td>MSG</td>
<td>Monosodium Glutamate</td>
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<tr>
<td>MOH</td>
<td>Ministry of Health, Ghana</td>
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<tr>
<td>MOFA</td>
<td>Ministry of Food and Agriculture, Ghana</td>
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<tr>
<td>Na</td>
<td>Sodium</td>
</tr>
<tr>
<td>NIA</td>
<td>National Institute on Aging</td>
</tr>
<tr>
<td>NCA</td>
<td>Ghana National Communication Authority</td>
</tr>
<tr>
<td>NCC</td>
<td>Na+-Cl– transporter</td>
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<tr>
<td>NCDs</td>
<td>Non-Communicable Diseases</td>
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<td>NGOs</td>
<td>Non-Governmental Organizations</td>
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<tr>
<td>NHANES</td>
<td>The National Health and Nutrition Survey</td>
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<td>NHIS</td>
<td>National Health Insurance Scheme</td>
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<tr>
<td>NHMRC</td>
<td>National Health and Medical Research Council</td>
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<tr>
<td>NMIMR-UG</td>
<td>Noguchi Memorial Institute of Medical Research, University of Ghana</td>
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<tr>
<td>OPD</td>
<td>Out-Patient Department</td>
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<tr>
<td>OR</td>
<td>Odds Ratio</td>
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<tr>
<td>RCTs</td>
<td>Randomized Controlled Trials</td>
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<tr>
<td>ROMK</td>
<td>Renal Outer Medullary K+ channel</td>
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<tr>
<td>PAHO</td>
<td>Pan African Health Organization</td>
</tr>
<tr>
<td>PRDF</td>
<td>Partnerships &amp; Research Development Fund</td>
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<tr>
<td>PRISMA</td>
<td>Preferred Reporting Items for Systematic Reviews and Meta-Analyses</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Full Form</td>
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<tr>
<td>PROSPERO</td>
<td>International Prospective Register of Systematic Reviews</td>
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<tr>
<td>PURE</td>
<td>Prospective Urban Rural Epidemiology</td>
</tr>
<tr>
<td>PP</td>
<td>Pulse Pressure</td>
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<tr>
<td>RAAS</td>
<td>Renin–Angiotensin–Aldosterone System</td>
</tr>
<tr>
<td>RDA</td>
<td>Recommended Dietary Allowances</td>
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<td>SA</td>
<td>South Africa</td>
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<tr>
<td>SBP</td>
<td>Systolic Blood Pressure</td>
</tr>
<tr>
<td>SHARE</td>
<td>Study on Health and Retirement in Europe</td>
</tr>
<tr>
<td>SNP</td>
<td>Single-Nucleotide Polymorphisms</td>
</tr>
<tr>
<td>SSA</td>
<td>Sub Saharan Africa</td>
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<tr>
<td>UIC</td>
<td>Urinary Iodine Concentration</td>
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<tr>
<td>UIE</td>
<td>Urinary Iodine Excretion</td>
</tr>
<tr>
<td>UK</td>
<td>United Kingdom</td>
</tr>
<tr>
<td>UN</td>
<td>United Nations</td>
</tr>
<tr>
<td>USI</td>
<td>Universal Salt Iodization</td>
</tr>
<tr>
<td>WHA</td>
<td>World Health Assembly</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organization</td>
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<tr>
<td>WHO-SAGE</td>
<td>World Health Organization’s Study on global AGEing and adult health</td>
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<tr>
<td>WHS</td>
<td>World Health Survey</td>
</tr>
<tr>
<td>WtHR</td>
<td>Waist to Height Ratio</td>
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Publications constituting this thesis

The chapters of this thesis have been prepared for publication as follows:

Peer review publications


Conference Presentations


Other publications

This publication was related to the outcomes of this study.


Prizes and Awards

1. HDR travel grant to present at the International conference on Non-Communicable Diseases in Ghana, February 15-16, 2019.


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Chapter 1

Hypertension prevalence, risks factors for hypertension and salt reduction strategies

1.1 Introduction

This chapter provides an overview of the global burden of hypertension, its scope, measurement, risk factors and management through a narrative literature review. It gives an insight into hypertension in low- and middle-income countries (LMICs) with reference to Ghana. It further explains the link between hypertension and salt intake by reviewing literature on the role of sodium (Na) and potassium (K) vis-a-vis vascular conditions and discusses population salt reduction strategies and interventions. This chapter also highlights the gaps in the literature which will be addressed in subsequent chapters of this thesis.

1.2 Hypertension

Cardiovascular diseases (CVDs) are one of the major health concerns facing governments and nations globally. CVDs accounts for the greatest number of deaths every year, with 17.9 million death globally in 2016, representing 31% of all global deaths [1]. Though age-standardized CVD mortality rates have decreased globally between 2006 and 2016 - more than three-quarters of these deaths have been attributed to heart disease and stroke and increased numbers of deaths related to these causes are expected to reach 23.3 million by 2030 [1, 2]. CVD burden continues to be relatively higher in LMICs compared to high-income countries (HICs) due to adverse lifestyle-related factors associated with the nutrition transition and poor-quality care [1, 3]. Risk factors for CVD, including hypertension, hypercholesterolemia and high body mass index (BMI) are among the major contributors to higher disability-adjusted life years [4].

Hypertension is serious medical condition in which blood pressure (BP) is consistently elevated in the blood vessels [5] and is now considered to be one of the most important independent risk factors for developing CVD [5-7]. Of the 17 million CVD deaths in 2008, complications of hypertension accounted for 9.4 million [8, 9]. Evidence from clinical
research studies and randomized controlled trials (RCTs) attributed the decline in stroke mortality to hypertension treatment and control strategies [10]. Similarly, posthoc meta-analysis of 123 studies emphasized that systolic blood pressure (SBP) should be reduced to less than 130 mm Hg to reduce CVD [11]. The relationship between hypertension, coronary artery disease (CAD) occurrence and premature death is well established [12-14]. Data from several studies have described hypertension as the most prevalent risk factor for stroke and has been reported in about 64% of patients with stroke [15, 16]. Findings suggest that at ages 40 – 69y, each 20 mm Hg increase in SBP or each 10-mm Hg increase in diastolic blood pressure (DBP), is associated with more than two-fold increase in stroke death [15].

Prolonged hypertension is also a risk factor for developing heart failure unless other mitigating factors such as reduction in excess salt intake exist [16]. In the Framingham Heart Study, which incorporated 5,143 participants, hypertension preceded the onset of heart failure (HF) in more than 90% of all newly diagnosed HF patients in a 20-year follow-up [17]. Further analyses indicated that hypertension was the most attributable risk factor to HF and responsible for 39% of cases in men and 59% in women. At age 80, the lifetime risk of developing HF was about 20% in the Framingham cohort, and this risk doubled for participants with BP of 160/100 mm Hg compared with those with 140/90 mm Hg [18]. However, among populations with either acute or chronic HF, increased SBP is associated with greater negative health outcomes [13, 16].

Globally, hypertension has been increasing over time; the number of people living with hypertension increased from 600million in 1980 to 1billion in 2008 [19], while in 2015 one in four men and one in five women had hypertension [20] making it challenging to achieve World Health Organization’s (WHO) target of a 25% decline by 2025 [21].

1.3 Hypertension in LMICs

Over 75% of global CVD deaths are occurring in LMICs whose populations have marginal access to integrated primary health care programmes and effective or equitable health care services to address CVDs [1, 22]. Additionally, CVDs were more prevalent among younger, middle-aged groups in LMICs. For example, in sub-Saharan Africa (SSA) half of CVD deaths occurred among the 30–69 age bracket [23]. A projected
economic loss of $3.7 trillion attributed to CVDs was estimated between 2011 and 2015, representing about 50% of the NCD economic burden and 2% of Gross Domestic Product (GDP) across LMICs [24]. Populations in LMICs may experience a higher burden of hypertension in comparison to the global average due to factors such as the ongoing nutritional transition, increasing trends in sedentary lifestyle, inadequate health care systems and the non-control of modifiable risk factors LMICs. Projections estimate that three-quarters of the world’s hypertensive population will reside in LMICs within the next decade [25]. China, for example, reported 20% all deaths were from hypertension in 2005 [26]. The overall prevalence of hypertension in China has risen substantially between 2002 and 2010 – from around 20% to 34% [27-29] while a 68% increase in hypertension within sub SSA by 2025 has been predicted [30]. Despite the interventions and use of innovative approaches, BP levels remain high in several LMICs [31]. Findings from a systematic review of hypertension prevalence across LMICs reported a pooled hypertension prevalence (for all 242 studies) of 32.3% [32]. A recent systematic review and meta-analysis of hypertension prevalence in older adults from 15 African countries indicated a prevalence range of 22.3% to 90.0% [33].

Health systems in many LMICs do not have the capacity to diagnose and manage hypertension successfully [34, 35]. As the means of diagnosing hypertension becomes possible in LMICs, along with the absence of adequate prevention and control measures, the former can account for rapid increase in the prevalence of hypertension [36]. For example, evidence from a series of cross-sectional studies conducted over a period 25y in India indicated rising hypertension levels from 29.5% in 1992-1994, to 36.0% in 2015 [37, 38]. In many countries in Africa, more than 40% (and up to50%) of adults are estimated to be hypertensive however, many individuals are living with undiagnosed, untreated and/or uncontrolled hypertension [39, 40].

1.4 Hypertension awareness, treatment and control in LMICs

Though many national and global organizations have endorsed the importance of identification and control of hypertension [41, 42], poor access to available and effective medicines, together with challenges in rolling out screening programmes and the burden
of already stretched healthcare services remain barriers to hypertension control. Other setbacks include limited knowledge about prevention and management of hypertension among health practitioners and patients alike, and non-adherence to treatment among hypertensives [43]. Additionally, lack of governmental commitment in many LMICs to comprehensive public health policies to manage hypertension compounds the difficulties [44]. Despite global efforts to combat hypertension, treatment and control rates are very low in LMICs [45].

LMICs disproportionately share low levels of hypertension awareness, treatment and control with rising hypertension [45, 46]. In a Chinese population-based screening project that recruited 1,738,886 participants, 44·7% (95% CI 44·6-44·8) of the hypertensives were aware of their diagnosis, 30·1% of whom (95 CI 30·0-30·2) were taking antihypertensive medications, and only 7·2% (95% CI 7·1-7·2) had achieved BP control [47]. Similarly, a Vietnam cross-sectional survey involving 9,832 adults reported that only 48.4% of hypertensives were aware of their hypertension, 29.6% were receiving treatment for the condition and only 10.7% had controlled BP [48]. A community-based study of 1,203 elderly participants from two sites in Bangladesh and three sites in India reported that, of those with hypertension, only 45% were aware of their hypertension, 40% were on antihypertensive medication and 10% had the condition controlled [49]. Evidence from SSA indicated that, of those with hypertension only 27% (95% CI, 23%-31%) were aware of their condition. Overall, 18% (95% CI, 14%-22%) of hypertensives were receiving treatment across the studies, and only 7% (95% CI, 5%-8%) had controlled BP [50].

1.5 Measurement of Hypertension

Different guidelines are available worldwide regarding how BP is classified. Most guidelines classify hypertension as SBP ≥ 140 mmHg and/or ≥ DBP 90 mmHg in individuals 18y and older, apart from in the most elderly (<150/90mm Hg for 80y+) based on an average of two or more measurements taken after the participant has been seated, legs uncrossed, for about 3 minutes. This cut-off is based on the existing evidence which shows that treatment of patients to reduce BP below these values is beneficial in reducing the risk of developing NCDs [51]. This guideline is supported by the American Heart
Association, American College of Cardiology, Centres for Disease Control and Prevention, American Society of Hypertension and the International Society of Hypertension [42, 52]. However, RCTs (2014 evidence-based guidelines for management of hypertension in adults) recommended a new target <150/90mm Hg for ages 60+y due to physiological changes taking place among that age group [53]. Tables 1.1 and 1.2 are the hypertension classifications.

Table 1.1 BP classification

<table>
<thead>
<tr>
<th>Category</th>
<th>Systolic (mm Hg)</th>
<th>Diastolic (mm Hg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>&lt;120</td>
<td>And &lt;80</td>
</tr>
<tr>
<td>Elevated</td>
<td>120-129</td>
<td>Or &lt;80</td>
</tr>
<tr>
<td>Stage 1 hypertension</td>
<td>130-139</td>
<td>Or 80-89</td>
</tr>
<tr>
<td>Stage 2 hypertension</td>
<td>≥140</td>
<td>Or ≥90</td>
</tr>
</tbody>
</table>

New ACC/AHA High Blood Pressure Guidelines [54].
Table 1. Definition and classification of office BP levels according to the 2018 ESH/ESC guidelines for the management of arterial hypertension

<table>
<thead>
<tr>
<th>Category</th>
<th>Systolic (mm Hg)</th>
<th>Diastolic (mm Hg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimal</td>
<td>&lt;120</td>
<td>And &lt;80</td>
</tr>
<tr>
<td>Normal</td>
<td>120-129</td>
<td>and/or 80-84</td>
</tr>
<tr>
<td>High normal</td>
<td>130-139</td>
<td>and/or 85-89</td>
</tr>
<tr>
<td>Grade 1 Hypertension</td>
<td>1 140-159</td>
<td>and/or 90-99</td>
</tr>
<tr>
<td>Grade 2 Hypertension</td>
<td>2 160-179</td>
<td>and/or 100-109</td>
</tr>
<tr>
<td>Grade 3 Hypertension</td>
<td>3 ≥180</td>
<td>and/or ≥110</td>
</tr>
<tr>
<td>Isolated Hypertension</td>
<td>≥140</td>
<td>And &lt;90</td>
</tr>
</tbody>
</table>

The BP category is defined by the highest level of BP, whether systolic or diastolic. Isolated systolic hypertension should be graded 1, 2 or 3 according to systolic BP values in the ranges indicated; ESH, European Society of Hypertension; ESC, European Society of Cardiology [42].

1.6 Risk factors for Hypertension

In most cases, hypertension has no identifiable physiological cause and is generally classified as primary, essential or idiopathic. In a few cases, a weakened renin-angiotensin system, increased adrenal medulla catecholamine secretion or increased adrenal cortex aldosterone secretion may result in renal alterations that could result in some form of hypertension [55, 56]. There are many known lifestyle risk factors that are associated with hypertension among various populations [39, 57] such as ageing, poor diet, excessive alcohol intake, lack of physical activity excess weight and exposure to persistent stress and are summarized further in Figure 1.1.
Figure 1.1 Risk factors of hypertension
1.6.1 Age
The association between age and risk of hypertension is well known [58-62]. Rising BP is regarded as a common occurrence as people age with raised BP more prevalent among older people. Longitudinal data from the Framingham Heart Study, which followed participants for three decades, demonstrated a continuous rise in SBP between the ages of 30 and 84 years or over. Diastolic blood pressure however, has a varying pattern with ageing, increasing until the fifth decade and slowly decreasing from the age of 60 to at least 84 years of age. This causes a steep rise in pulse pressure with ageing [63]. In support, SBP was found to progressively increases with age, leveling at an average of about 140 mm Hg by age 80y [64]. The prevalence of hypertension is more than doubled in the elderly than in the young population with more than two-thirds of individuals aged 65 and above being hypertensive [65, 66]. In recent years, metabolic syndrome and hypertension are increasingly seen in the middle-aged and young populations. Among young adults (18-39 years), approximately 20% of men and 15% of women have diagnosed hypertension with an expected increase in prevalence due to rising rates of obesity [67]. Stiffening of blood vessels with age is conventionally associated with occurrence of systolic hypertension [68]. The wall of large arteries, thicken and lose elasticity over time, resulting in an increase in pulse wave velocity which increases both systolic and pulse pressure. Therefore, aging-related hypertension is characterized by a significant increase in systolic blood pressure with no change or even a decrease in diastolic blood pressure [69, 70]. Aging also causes an overall decline in cardiac output, heart rate, stroke volume, intravascular volume, renal blood flow and plasma renin activity, all of which are indicative of increasing BP [69]. Subsequently, the kidneys become less efficient at excreting salt loads, thereby compounding the effect of ageing on rising BP [70].

1.6.2 Gender
Though several studies have showed conflicting results, men generally are at a greater risk of hypertension than premenopausal women of the same age [71, 72, 73]. Men have greater prevalence of hypertension from 20 until age 65 where the gap between the genders is narrowed, yet more women over age 75 remain hypertensive [74]. NHANES data which studied 10,380 people from 1999 to 2006, indicated a 36.3% prehypertensive
status, of which men had a much higher prevalence of prehypertension prevalence compared with women [75]. This finding is further supported by a recent meta-analysis of 250,741 individuals (120,605 men and 130,136 women) from 13 countries, where the pooled prevalence of prehypertension was 40% among men vs. 33% among women [76]. These data further demonstrated that young women between 20-40y were relatively protected from developing hypertension compared with their male counterparts. There is substantial evidence that male and female hormones, particularly testosterone and estrogen may be responsible for gender-associated differences in BP status, but the underlying mechanisms for such occurrence needs further study [77-78]. Estrogen has the potential to regulate endothelial vasodilation, inhibit sympathetic and renin-angiotensin system (RAS) activity, enhance the production of endothelin, reduce oxidative stress, increase antioxidant production and reduce inflammation - all of which may alter BP (79-81). After menopause, where estrogen levels fall a rapid increase in the prevalence of hypertension to about 75% is evident in women [82]. The difference in hypertension prevalence across age and sex may be partially attributed to true biological differences; however, gender-specific differences in access to care may also partially account for this [83].

1.6.3 Area of Residence
Residential location often influences exposure to environmental risk factors associated with lifestyle and access to healthcare. Generally, urban residence is associated with a higher risk of hypertension compared to rural dwelling. Evidence from several LMICs suggest higher prevalence of hypertension in urban areas [84-86]. That notwithstanding, data from the Chinese Health and Retirement Longitudinal Study 2015 indicated that rural residents were more likely to have undiagnosed hypertension compared to their urban peers [87]. Comparably, Pakistan’s National Diabetes Survey, 2016–2017, reported hypertension prevalence to be 44.3% and 46.8% for urban and rural dwellers, respectively [88], while hypertension prevalence among Zambian adults in the rural setting (46.9%) was double that observed in urban areas (22.9%) [89]. Despite contradictory findings, hypertension has increased in both urban and rural areas over time. A general increase in hypertension prevalence from the previous decade was reported between 2000 and 2016, ranging from 13-70% in rural, and 12-65% in urban
settings [90-94] necessitating urgent public health interventions by both local and international health bodies [57, 95].

1.6.4 Heredity
Several studies have identified associations between genetic polymorphisms and the development of hypertension [96, 97]. It is estimated that heredity contributes 30–60% to the pathogenesis of essential hypertension [98-100]. The interaction between genes and environment, may influence risks of hypertension among different populations [101]. Genetic predisposition for increased BP spanning the lifetime has been investigated in a number of studies showing that higher genetic risk scores in childhood had significantly higher DBPs and were more likely to be hypertensive in adulthood compared to those with a lower risk score [102, 103].

Several twin and family studies that have relied on both conventional office BP measurements and ambulatory BP (ABP) measurements have shown substantial genetic contributions to individual differences in BP [104-106]. Various SNPs have been found to influence hypertension in many pediatric populations studied recently [107, 108]. In terms of ABP, heritability estimates ranging from 22% to 62% for SBP and from 38% to 63% DBP have been reported [106, 109, 110]. In a study to explore the familial aggregation and heritability of hypertension among the extended family, hypertension distribution was found in first, second and third-degree relatives with hypertension prevalence reducing as level of relatedness declined [101]. Similarly, twin studies have demonstrated the heritability of SBP and DBP based on studies conducted in over 4000 twin pairs from seven countries. Findings from this study showed a range of 52-66% heritability in SBP and 44-66% in DBP, with differences in sex and shared family environments [104].

1.6.5 Diet
1.6.5.1 Salt consumption
Several nutrients have different impacts on BP, however, many meta-analyses have established well-known effects of Sodium (Na) and potassium (K).

Sodium, consumed as salt (NaCl) is considered to be a major risk factor in cardiovascular events [111-113]. Sodium is required by the body to ensure acid-base balance, maintain plasma volume, and transmit nerve impulses [114, 115]. Though essential, Na is needed
only in small quantities by the human body [116]. Sources of Na can be described as
discretionary (salt added to food during cooking or at the table) or non-discretionary
(salt present in foods, which is inherent, or which were added during food processing)
[117-119]. While low amounts of Na are naturally found in vegetables, oils and cereals,
meat and fish products contain relatively higher amounts. Food processing plays a large
role in the amount of Na present in foods [114]. Processed foods contribute the most to
salt consumption worldwide, with breads, meat and meat products, bakery products,
instant noodles, salted preserved foods, milk and dairy products providing more than
70% of all salt consumed in westernized diets [120]. In LMICs, a much greater
contribution of salt in the diet is provided through discretionary sources [121, 122].
There is a strong evidence from various studies showing a positive and direct
relationship between salt consumption and BP. The International Study of Sodium,
Potassium, and Blood Pressure (INTERSALT), involving over 10,000 participants aged
20-59y from 32 countries provided both within and between population estimates of
24hr Na excretion and found a significant positive relationship between 24hr Na
excretion and SBP. Adjusting for underestimation, Na intake higher by 100 mmol/d was
accompanied by a corresponding higher SBP/DBP by about 3-6/0-3 mm Hg. This
relationship was found for both normotensives and hypertensives participants [123]. In
the International Population Study on Macronutrients and BP (INTERMAP) studies,
significant positive associations between 24hr urinary Na excretion and urinary Na/K,
and BP were reported among 4,680 participants from 17 populations across five
countries [124].
Population-wide intervention studies have demonstrated that reduced salt consumption
results in a corresponding decline in population-level BP. In a 2-year study, extensive
health education to reduce salt intake, particularly from foodstuffs known to contribute
significantly to salt in the diet of that population, resulted in approximately 50%
reduction in salt intake between intervention and control villages and was associated
with a decrease of 13/6mm Hg in BP in the intervention group [125]. Another
intervention study conducted in two communities in northeastern Japan demonstrated
a decline in salt consumption by 2.3 g/day through dietary counselling and an associated
reduction of 3.1 mm Hg in systolic BP [126]. Conversely, studies that did not achieve significant reduction in salt intake failed to accomplish declines in BP [113, 127]. A meta-analysis of randomized trials demonstrated that a long-term gradual decline in salt consumption resulted in substantial reductions in BP, in both hypertensive and normotensive individuals, irrespective of gender, age and ethnicity, with a variation in the gradient of the decline in BP within different populations, and indicative of a dose-response relationship [128, 129]. Similarly, the Dietary Approaches to Stop Hypertension (DASH)-sodium trial showed a dose-response relationship with BP reduction [130]. The WHO recommends <2gNa/day, equivalent to 5g salt/day beyond which there is risk for developing CVDs. However, global mean Na intake is almost twice the WHO recommendation [131]. Sodium intakes exceed the recommended levels in almost all countries with small differences by age and sex [132]. Some studies have emphasized a U-shaped relationship between Na intake and CVD mortality which has raised a debate about the optimal lowest intake of salt [133, 134]. The Prospective Urban Rural Epidemiology (PURE) study suggested that salt reduction efforts should be limited to only populations where salt intake exceeds 12.7 g/day. However, the findings from the PURE study have been widely criticized for their methodological flaws, such as using spot urine samples instead of 24hr collections and procedural biases [135-139]. Reduction of salt consumption in countries such as United Kingdom (UK) [140] and Finland [141] have refuted claims of the PURE study [142] by demonstrating public health benefits [143, 144]. In England, mean population level salt intake declined from 9.5 g/day to 8.1 g/day between 2003 and 2011 which, in turn, resulted in substantial decline in population BP and mortality from stroke and ischaemic heart disease [145]. The body of evidence to support global salt reduction to 5g/day is considered overwhelming [146].

Some studies have suggested that the association between Na consumption and development of hypertension may be due to the degree of salt sensitivity among populations [147]. Most excess salt consumed is excreted from the body by the kidneys or as sweat. Yet, for some people, response to limited or large intake of salt results in differential changes in BP (‘salt sensitive’) [148]. Several mechanisms including blunted
activity of the renin–angiotensin–aldosterone system (RAAS) and dysfunctional or
defective Na+/Ca2+ transport and exchange system, have been suggested to be implicit
in this phenomenon [149] as such, individuals respond to salt intake differently
irrespective of their hypertension status [150]. In populations where BP changes are
parallel to changes in their salt consumption, a higher BP is needed to sufficiently excrete
Na [151]. In that sense, salt sensitivity may be associated with raised cardiovascular
morbidity and mortality [152, 153]. The causes underpinning salt sensitivity trait have
not been investigated thoroughly [154], but there is evidence suggesting genetic
proposition may play a role [153, 155]. Other factors include race/ethnicity, age, gender,
BMI and diet [148, 156]. Salt sensitivity is particularly common in older adults, people of
African descent and people with hypertension or other related diseases [157].

1.6.5.2 Potassium

Potassium is an important micronutrient required for regulating and maintaining body
fluid volume and acid-base balance [158]. An inverse relationship has been established
between K intake and BP, and more generally with CVDs risks [159, 160]. A recent meta-
analysis of 11 cohort studies reported an increased K intake was associated with reduced
risk of stroke [161]. In another meta-analysis of 32 randomized controlled trials, SBP and
DBP were reduced by 4.9 mm Hg and 2.7 mm Hg, respectively, when K consumption
was increased by 75mmol/day (median) in both hypertensive and normotensive
populations [159]. Not all studies are consistent; however, a meta-analysis including
only hypertensive participants showed no association between increased K and BP,
[162]. In response to the large body of evidence that supports a beneficial role of dietary
K intake on blood pressure regulation, the WHO suggests an intake of at least 90
mmol/day (3510 mg/day) from food sources for adults and downward adjustment for
children based on their energy requirements[]. Many populations around the world
consume less than the recommended amount of K, thus making the achievement of the
WHO global target of 25% hypertension reduction by 2025, challenging [163].
1.6.5.3 Na/K Ratio

Both Na and K intakes are associated with BP regulation, however the ratio between these two cations may be more important than either one alone. Several mechanisms have been suggested as means by which the interaction between Na and K may control BP. One such, is molecular mechanisms implicated in the retention of sodium and loss of K (Fig. 1.2).

Figure 1.1 Molecular Mechanisms Implicated in the Retention of Sodium and Loss of Potassium by the Kidneys in Primary Hypertension. Solid arrows indicate an increase or stimulation, and the broken arrow indicates inhibition. Numbers on the left denote the approximate percentage of reabsorption of filtered sodium in each nephronal segment during normal conditions. Several influences acting on the luminal sodium transporters and the basolateral sodium pump stimulate sodium retention and potassium loss. Promotion of sodium reabsorption by the activated epithelial sodium channel (ENaC) generates a more negative luminal membrane voltage (Vm) in the collecting duct that enhances potassium secretion through the luminal potassium channel and promotes kaliuresis. NHE-3 de-notes sodium–hydrogen exchanger type 3, ACE angiotensin-converting enzyme, NKCC2 sodium–potassium2 chloride cotransporter, and NCC sodium–chloride cotransporter. PST 2238 (rostafuroxin) antagonizes the effect of digitalis-like factor on the sodium pump [164].

Furthermore, renal vascular K channels could be implicit in the regulating BP [165]. Reabsorption of Na and K secretion in the distal nephron is fundamental in the long-
term control of arterial pressure [166]. As such, even in hypertensives, a high K diet could significantly reduce the thickening of arterial walls, thus reducing BP [167]. The interdependency between Na and K and their effect on BP is well known [164]. Several studies have demonstrated that a high K intake lessens the effect of high salt intakes on BP levels thereby reducing CVD risk [168-170]. To improve dietary Na/K ratio, many studies have assessed dietary strategies such as the DASH diet, either with or without salt restriction [130, 171, 172]. The DASH diet recommends 2300mg of sodium intake per day.

The Na/K ratio may be better placed and can be used for dietary approaches meant to reduce BP across populations [173]. Proportions of Na and K is an essential metric in relation to the presence and development of CVDs and death [167, 172]. Evidence is also provided by experimental RCTs [175, 176]. A reduction in the urinary Na/K molar ratio from 3.09 to 1.00 results in a 3.36 mm Hg reduction in population systolic BP [173, 177]. In support, the WHO has emphasized that attaining the targets for both Na and K consumption levels would result in an Na/K molar ratio of about 1.00 [163]. Relatively, Na/K molar ratios less than 2 predicted the least probability for CVD occurrence [169]. At the same time, a lowered Na/K ratio is indicative of a higher quality diet [178] with dietary approaches to reduce BP shown to be effective and used as evidence to provide global recommendations for upper limits of Na and minimum K consumption levels [179].

1.6.5.4 Iodine Intake

Iodine is a trace element that is found in most vegetables and seafood and is very important for optimal functioning of the thyroid gland. Iodine is required for normal physical growth, particularly during pregnancy and infancy. Due to the absence of iodine in a large variety of everyday foods, it has become a public health concern particularly for children and lactating mothers [180]. Globally, approximately 2 billion people are living with iodine deficiencies (ID), out of which about 50 million show severe manifestations [181]. Inadequate iodine has been implicated in increased risk of stillbirths, abortions, perinatal mortality, congenital abnormalities, cretinism impaired growth [181, 182]. Iodine deficiencies cause irreparable but preventable brain damage...
and are associated with lower intelligent quotient (IQ) among children born to mothers who were iodine deficient during pregnancy [183, 184]. Urinary iodine is mostly used in assessing population iodine intake with a recommended median urinary iodine concentration (UIC) of ≥100μg/l [180].

The WHO upon its evaluation of the global magnitude of the ID, and in keeping with its mandate of monitoring each country’s progress towards addressing global iodine deficiency disorders (IDD), as a public health concern, launched the universal salt iodization (USI) programme in 1991[185]. Over the years, various food vehicles such as bread, milk [186], water [187] and, most widely, salt have been used for iodine fortification. To meet the iodine requirements of a population it is recommended to add 20 to 40 parts per million (ppm) of iodine to salt (assuming an average salt intake of 10 g per capita/day). Most countries have implemented the USI and ID have been greatly reduced, with 66% of households worldwide using iodized salt [188, 189].

While USI strategies are emphasized by the WHO, member countries are encouraged to ensure its compatibility with salt reduction, so that both public health goals of reducing salt intake and maintaining optimal iodine consumption are achieved [190].

1.6.6 Physical Activity
The relationship between physical activity and CVDs in general has been well established [191-194]. Large prospective studies from HICs have demonstrated an inverse relationship between self-reported physical activity and cardiorespiratory fitness, and hypertension [195, 196]. In the Aerobic Center Longitudinal Study (ACLS), participants who maintained or improved fitness (metabolic equivalents (METS), 0.46-5.64) had a 26% and 28% lower risk of incident hypertension, respectively, compared with those who lost fitness overtime (METS < 0.46) [197]. Similarly, in another study, participants with reduced cardiorespiratory fitness over 5y of follow-up, had an increased risk of hypertension compared to participants with improved cardiorespiratory fitness [198].

Several studies have shown positive impacts of physical activity on hypertension management with associated declines in BP as high as 5–7 mm Hg for both SBP and DBP [199, 200]. For the most part, physical activity has been linked with acute substantial
declines in SBP, with its most profound impacts were well demonstrated in hypertensives [201].

The decline in BP with physical activity may result from mitigation in peripheral vascular resistance, which may be due to neurohormonal and structural responses, with reductions in sympathetic nerve activity and increased arterial lumen diameters [202]. Figure 1.3 depicts the effect of physical inactivity on hypertension.

![Diagram of physical inactivity effects](image)

Figure 1.2 Hypothesized considerations by which physical inactivity may influence risk for hypertension and cardiovascular complications [203]

Other explanations for BP decline included beneficial impacts on oxidative stress, inflammation, endothelial function, arterial compliance, body mass, renin-angiotensin system activity, parasympathetic activity, renal function, and insulin sensitivity [192]. Variability in types and intensity of physical activity together with environmental and hereditary aspects may result in significant between and within-study variation in participants’ BP response to physical activity [204].
1.6.7 Alcohol
Alcohol consumption is a risk factor for several disease conditions including certain cancers, liver cirrhosis and CVDs [205]. The relationship between alcohol consumption and BP has been investigated in several epidemiological studies. Regular consumption of alcohol was found to increase BP even among men who reported moderate consumption. Women who reported excessive alcohol consumption were three times more likely to be hypertensive, and heavy consumers had a 70% probability of developing hypertensive [206-208]. Longitudinal studies indicated that, compared with abstainers, drinking frequency of 2 or more times per week was associated with a significant increase in the risk of hypertension in both genders [209]. The link between high levels and specific patterns of alcohol consumption (such as binge drinking) and growing risk of hypertension is also well established [206, 209, 210]. Additionally, among the youth, increased risks for hypertension have been reported for females consuming more than 14 drinks per week, and for men consuming between 15–28 drinks per week, together with monthly heavy drinking [211]. However, there is some evidence that indicates moderate consumption of alcohol may have health benefits [212, 213].

Due to the immense burden that alcohol use poses on society, particularly in SSA where consumption rates have been consistently high since 2005 [214, 215], monitoring and surveillance at both local and international levels are recommended within [216].

1.6.8 Body weight and obesity
A linear association between obesity (BMI ≥ 30) and hypertension has been documented in several epidemiological and clinical studies [217, 218]. Obesity is a worldwide epidemic with a global fatality rate of at least 2.8 million people annually [219], and a major risk factor for hypertension [220-223]. It is established that this association exists from early in life at around age 8–11y [224]. In a systematic review involving 30,044 individuals across 13 African countries, obese participants were more than twice as likely to be hypertensive [225]. Data from a 30y follow-up in the Framingham Heart Study, indicated that more than three-quarters and two-thirds of primary hypertension in males and females, respectively, was attributed to excess weight gain [226]. The Tecumseh Study also reported higher waist/hip ratio in the hypertensive participants compared to the non-hypertensive group. Additionally, familial predisposition to hypertension was associated with excess weight accumulation, suggesting an
association between the mechanisms that cause a rise in BP and those that stimulate increased food intake or sedentary living [226]. Clinical studies have emphasized the importance of maintaining a BMI of <25 kg/m², as a prudent way to prevent primary hypertension and have demonstrated weight loss to be an effective strategy in hypertension reduction [218, 228].

Despite the enormous evidence implicating the role of excess weight gain in higher BP, not all obese persons are hypertensive. Yet, individuals identified as obese normotensives have higher BP than their age-matched peers who have lower body weight [229]. Not only the amount of excess weight is important, but the distribution of body fat, with visceral abdominal fat being a better predictor hypertension than BMI [230].

Mechanisms linking obesity to hypertension are not well established. However, studies have shown that blood volume and osmosis taking place in the kidneys play important roles in the development of hypertension [231]. Obese populations may have relatively higher likelihood of being hypertensive due to the increased presence of hyperinsulinemia. This may trigger the stimulation of the sympathetic nervous system, which in turn, may cause a rise in BP either through vasoconstriction or increased Na retention [232]. Other mechanisms postulated included activation of the renin–angiotensin–aldosterone system, abnormal levels of certain adipokines such as leptin, altered spectrum of cytokines and the role of perivascular adipose tissue damage [233-235]. Given the rising trends of obesity worldwide [219], body weight management may be an effective remedy for hypertension prevention.

1.6.9 Smoking
Though it is overwhelmingly established that cigarette smoking causes various adverse cardiovascular events [236-238], studies on the association between cigarettes smoking and hypertension have produced conflicting results [239-242]. The nicotine in cigarettes has been described as an adrenergic agonist, with a sympathomimetic ability to raise the heart rate and BP levels [243]. Smoking has a direct association with endothelial damage [14], which in turn, plays an essential role in development of hypertension [244, 245]. In a case control study measuring ambulatory systolic BP in hypertensive smokers and
non-smoking hypertensives, smokers recorded a higher mean daytime ambulatory SBP than nonsmokers [246]. A meta-analysis involving 16,980 participants from 18 countries across Africa showed that smoking was positively associated with hypertension [247]. However, findings from some epidemiological studies have provided contrasting findings. A five-year follow-up study conducted among Japanese men found that the adjusted mean change in BP of current smokers was lower than in nonsmokers [248]. The findings suggest that weight loss/gain may be a possible mediator of the association between smoking and BP.

Other epidemiological studies have reported no dose-effect association between frequency of smoking and SBP or DBP [249]. Another study on the effect of smoking on BP and resting heart rate found no causal relationship between smoking amount in current smokers and SBP nor DBP [250]. Smoking analyses are important in salt and BP studies, as smoking affects taste perception [241], and preference for salty food items [252].

1.7 Salt reduction strategies and interventions

Population salt reduction has remained high on the agenda of the United Nations (UN), the World Health Assembly (WHA) and WHO because of the looming pandemic of CVDs due to the persistent risk factors including increasing salt intake. In view of this, in 2011, world leaders pledged through a political declaration of the high-level meeting of the UN General Assembly on the Prevention and Control of NCDs, to decrease population’s access to poor diets. Subsequently, in 2013, the WHA approved 9 global voluntary targets for the prevention and control of NCDs, which included a 30% relative reduction in the intake of salt by 2025 [129]. In line with these projections, various policies, programmes, strategies and interventions have been developed which included actions and expectations from governments, civil societies, manufacturers, retailers, consumers, and the general public [57]. Though many countries are taking action to halt increasing salt consumption, more intensive effort is required, especially in LMICs where the risk of morbidity and mortality from hypertension far outweigh that present in HICs [253].
In addition to population salt consumption, many studies report on community knowledge, attitudes and behaviours in relation to salt use, and food sources that contribute most salt to the diet [122, 123, 132, 254]. These resources inform the planning of programmes and strategies to address excessive salt use. For example, in 2003/2004, in the UK, a salt reduction programme was initiated following a baseline study which determined salt consumption levels and food sources thereof. That study assisted in (1) setting a target for population salt intake and developing a salt reduction strategy; (2) setting progressively lower salt targets for different categories of food, with a clear time frame for the industry response (3) working with the industry to reformulate food to contain less salt; and (4) conducting consumer awareness campaigns. As a result, the salt content in many processed foods was reduced substantially from 9.5 to 8.1 g per day (p<0.05) over a 7 year period [138]. For each gram of salt eliminated from the usual UK diet, it has been estimated that 4,147 lives could be saved annually through a decline in stroke and heart attack mortality [255].

Periodic collection of information and monitoring of population salt intake is essential to track changes in salt content and sources of food. In the UK salt reduction programme [138], periodic assessments were carried to assess whether manufacturers and retailers were adhering to the voluntary reformulation targets and to determine whether there was a need to adjust the targets [256, 257]. Mongolia with an intervention that aimed to lower salt content in factory meals resulted in a 2.8 g/day reduction in salt intake, alongside improvements in consumer awareness, and an average of 1.6% reduction of salt content in bread among 10 bakeries in the country. These pilot salt reduction activities were influential in the drafting of the Mongolian National Salt Reduction Strategy, 2015−2025 [258].

Interventions through voluntary commitment and pledges from food industries are effective ways of reducing salt in the diet. This involves robust leadership from government, good partnership with the food industry, and availability of accurate information on the Na content of targeted foods, and the publication of monitoring data to encourage action by food industries [259]. For instance, in Kuwait, an agreement was reached between the Kuwaiti Ministry of Health and food industries to voluntarily reduce the salt content in bread and cheese over a 10 y period. Prior to this, the ministry,
in partnership with food industries, embarked on an education campaign on approaches for reducing salt content for the overall benefit to the country. The targeted 10% reduction in the salt content of bread was met in the first quarter of the 10-year period with an accompanying 1.7% decline in hypertension among adults in Kuwait between 2010 and 2014 [260]. The success story of Kuwait has motivated other countries in the Gulf particularly, Bahrain, Oman, Qatar, Saudi Arabia and the United Arab Emirates to initiate similar interventions [261]. Similarly, in the UK, voluntary salt reduction methods were associated with a 20–30% reduction of the salt content in processed foods which led to approximately 6000 fewer CVD deaths [138, 262].

Legislation on levels of salt permitted in foods and meals have been used in a few countries to promote reformulation. Food industries are mostly the target of this approach, where clear and gradual targets for maximum salt levels in specific foods are set to be reached within define time. Salt targets need to be achievable but also sufficiently stringent to result in the magnitude of population salt reduction that has been planned [263]. This involves setting the maximum levels of Na content of each food category and ensuring that the Na content of all food items within each category falls below the maximum level. Another method is to have weighted average targets for each food category. Using this approach, Na content level of food items within a certain food category can be altered to meet the overall average for that category. This latter approach is preferred by most countries but monitoring and surveillance required to ensure compliance is often unattainable and costly. Efforts such as food reformulation requires effective engagement with government, academia and industry and food supervision by international authorities to encourage uptake. Ideally and in many populations, initially targets are set for foods that contribute most salt to the diet [264] while other foods can be included later [259]. In South Africa (SA), the government passed new mandatory regulations specifying the maximum Na limits permitted in various categories of processed foods. The legislation was implemented in June 2016 with a further reduction of Na content in those foods and which came into effect by June 2019. The legislation included mechanisms to ensure compliance and enforcement, such as random and frequent chemical analysis of food products, and punitive measures for food manufactures that did not comply with the regulations [264].
As well as instituting salt reduction goals for the food industry, other interventions such as taxes on high-salt products, clear food labelling and effective health communication approaches have been shown to be beneficial [265]. Hungary introduced a public health product tax on salty snacks and condiments with Na content > 1g per 100g and > 5g per 100g, respectively. Similarly, in Portugal a value added tax is in place for salty foods [266]. Though the evidence is substantial in terms of the effectiveness of higher taxes on the control of tobacco use, the evidence of the impact of such strategies on salt intake is not yet well established [267].

Nutrition labelling (ie providing the list of the main nutrients in a food product) has been described as an effective way to influence for consumer food selection towards healthier choices that contain less salt. This approach requires food industries to declare the content of salt in their food products, thereby giving consumers the option to compare the salt content in similar products and make better choices. Labelling is most effective when carried out in conjunction with consumer education, communication and marketing strategies that explain the labels and its health implications. Many countries have mandatory regulations that specify type and number of nutrients to be labelled, whether the information appears on ‘front-of-pack’ or ‘back-of-pack’, the use of signposting such as colour codes to indicate the salt content in in food products, and whether the label provides further information to the consumer [259]. Labelling policies in Finland have influenced the food industry to reduce the salt content of products to avoid a “high salt” label. This policy resulted in 20–25% decline in the levels of salt in bread, meat products, cheeses and ready meals [268], and other food products [269]. As a result of the labelling policies and other salt reduction actions, a 4g salt/day decline in population salt consumption in Finland between 1979 and 2007 was reported [270, 271].

There have been suggestions for ‘shelf labelling’ at the point of purchase. This involves displaying warning signs in supermarkets and stores about the nutrient content of foods, so that consumers can make healthy choices. This intervention is presently being used in supermarkets in Marshall Islands (52). Another option is Australia’s FoodSwitch app which makes use of mobile phone applications allowing the retrieval of nutrient content information at the point of purchase and providing comparative alternatives to a food product based on the level of salt by scanning the bar code [272].
To target food consumed outside the home; in hotels, restaurants and cafés, menu nutrition labelling has been suggested, where regulations will require the hospitality industry to provide information relating nutrient composition and quantities on the menu or at a noticeable area within the premises. This has been successful in New York City where high-salt warning labels have been attached to menu items and information provided on levels of salt in composite meals [273].

Educating and communicating the health benefits of salt reduction is the most used intervention because of its relative ease and cost effectiveness [24]. When implemented successfully, this intervention has a high potential of changing dietary practices, by augmenting the desire for improved and reduced salt products, and generally enhancing the total health and wellbeing of populations. Education and communication approaches work better when they are implemented comprehensively within an overall environment that supports healthy eating [259]. A successful example is available from Vietnam where salt intake levels, consumer knowledge, attitudes and practice improved following a nutrition education campaign resulting in a 2.2g/day reduction in salt intake, with most of the population showing an increased understanding of the health risks associated with higher salt intake and embracing actions to reduce their salt intake [274]. Similarly, a school-based cluster randomized control trial involving 28 primary schools and their families in Changzhi, northern China, resulted in SBP reduction of 2.3 mm Hg and 9.5 mm Hg in adults (<60y) and older adults (60+y), respectively, after an 8-lesson (40 minute each) programme on salt reduction [275]. Effective communication for salt behaviour change has also been demonstrated in Australia in an 18-month study which involved comprehensive consultation with key stakeholders and the larger community. Through the use the Communication for Behavioural Impact (COMBI) framework, the ‘FoodSwitch’ app and the provision of a salt substitute, a significant decline of 0.8g/day of urinary salt equivalent excretion was achieved, together with a significant surge in knowledge related to salt reduction [276, 277]. Several studies have offered support for health education and communication as one of initial approaches and a compelling measure in salt reduction interventions [57, 259]. Varying approaches are recommended in terms of public advocacy, community mobilization, advertising, interpersonal communication and point-of-service promotion. That notwithstanding, limitations to
health education and communication needs to be identified to provide complementary methods better suited for constructs such as attitudes, perceptions and environmental/social support [257].

The WHO has introduced the ‘SHAKE’ package which is evidence-based resource and to assist WHO member states with the development, implementation and monitoring of salt reduction strategies, and to enable countries to achieve a reduction in population salt intake. The package outlines the policies and interventions which have proven to be effective, provides evidence of the efficacy of the recommended interventions, and includes a toolkit containing resources to assist member states to implement the interventions.

Few countries have engaged with all the strategies outlined in the ‘SHAKE the salt Habit’ but cost-effectiveness of salt reduction programmes to reduce morbidity and mortality from NCDs may drive further uptake in the future [278].

1.8 Hypertension in Ghana

Epidemiological studies on hypertension in Ghana over the past few decades have reported an increase in hypertension prevalence and an increased impact on disability and death [279, 280]. Hypertension was found to be a significant cause of renal and heart failure in Ghana [281] and remains consistently high in both urban and rural communities [282, 283]. Records obtained from the national hospital in Ghana between 1994 and 1998 showed that 11 % of deaths in adults aged 20y and older were as a result of stroke, with hypertension being the underlying factor [284]. In 2005, hypertension was described as the second principal cause of outpatient morbidity in adults older than 45y in Ghana [285]. In the capital city of Accra, hypertension increased from fourth place to become second only to malaria as the leading cause of outpatient morbidity in 2007 [286]. The incidence of hypertension in outpatient public health facilities in the country increased more than ten-fold from 49,087 in 1988 to 505,180 in 2007 [287]. Consequently, hypertension became the major cause of hospital admissions and death, due primarily to its association with heart disease and renal failure [281]. A nationwide study conducted in 2008 (WHO’s Study on global AGEing and adult health (WHO SAGE) Ghana W1) which included 5,526 nationally representative participants reported a high
hypertension prevalence of 58.9% using the BP threshold of ≥ 140/90 mm Hg [62]. Despite rising hypertension levels, awareness, treatment and control of the condition remains low [62, 288], indicative of the poor state of the health system in Ghana. There is an urgent need for the health system in Ghana to improve its performance to adequately address the rising demands of hypertension and related CVDs. Issues concerning funding, uncoordinated care, shortage of qualified health workforce, low insurance coverage and inconsistent supply of medication remain the main setback to effective healthcare delivery in Ghana [289, 290]. Despite the rising burden of hypertension and its related CVDs, the allocated budget to NCD prevention and management was meagre; approximately 80% of the health budget goes to infectious diseases [291]. There is also the challenge of traditional and faith-based healers whose practices and approaches to the management of hypertension is questionable and often not regulated [292].

1.9 Summary of evidence and gaps in literature

The narrative literature review has emphasized the rising trend of hypertension particularly in LMICs and highlighted the need for countries to develop strategies to better prevent and manage the occurrence. A modifiable risk factor for hypertension is diet, particularly salt consumption. However, population studies that assess relative hypertension and salt consumption are lacking in Ghana, a West African country that has a high burden of disease from hypertension. Gaps in the literature identified need for updated and valid data on population salt consumption levels, iodine intake levels, salt intake behaviours, and hypertension prevalence associated risk factors - to drive the salt reduction agenda through increased political will for policy formulation. This thesis will provide evidence to address some of the gaps.

1.10 Hypotheses

Hypertension prevalence has increased in Ghana particularly among older people and is associated with several modifiable risk factors.

Salt consumption is high in Ghana, in terms of WHO recommendations, and is associated with hypertension.
1.11 Research Questions

1. What are the dietary sources of salt in the diets of populations in LMICs?
2. What are the salt use behaviors of Ghanaians and how do they compare with SA population that has had a relatively increased salt reduction messaging and a salt legislation?
3. How much Na and K is consumed by Ghanaians at the population level and what is the relationship between urinary Na, K, N:K ratio, and hypertension?
4. Did BP change in Ghana between 2007/8 and 2019 and what were the determinants thereof?
5. How do salt and iodine intakes in Ghanaians compare with those of South Africans?
6. What do stakeholders in Ghana perceive to be viable approaches to addressing high salt intake and hypertension in the country?

1.12 Aims of the Study

Study 1 – To identify and synthesize available evidence related to dietary sources of salt in LMICs through a systematic literature review.

Study 2 – To examine salt knowledge, attitudes and practices of the Ghanaian population and compare it with a South African sample.

Study 3 – To determine the current population salt consumption level and its relation to BP in Ghana.

Study 4 – To identify any changes in BP levels between 2007 (WHO SAGE Ghana W1) and 2019 (WHO SAGE Ghana W3) and determinants thereof.

Study 5 – To ascertain iodine levels in relation to salt intake in Ghana and compare that to SA, a country with salt reduction legislation and effective salt iodization programme.

Study 6 – To conduct a high-level stakeholder meeting in Ghana, with the view of discussing the current hypertension situation in the country, salt consumption levels, and consolidate efforts at drawing the government’s attention to salt reduction approaches as a viable and cost-effective means of addressing hypertension.
1.13 Significance of the Study

Hypertension and salt consumption are both rising among adults in LMICs. This thesis will primarily provide current knowledge relative to Ghana on salt intake and hypertension to drive policy, planning and further research. It will serve as a strong foundation of knowledge for other LMICs as it draws comparisons with SA. By emphasizing the sources of dietary salt in LMICs and evaluating salt behaviours among two countries in SSA, the thesis will provide direction for advocacy and support for salt reduction interventions.

By evaluating the changes in BP overtime, this novel study will provide new knowledge about trends in BP, hypertension prevalence, awareness, treatment, control and the predictors of such in Ghana; which are critical in monitoring and policy formulation. The study will offer LMICs the opportunity to evaluate their salt iodization programmes alongside salt reduction strategies using Ghana as a case study, to ensure optimal iodine consumption while reducing salt intake. This study will create a road map for advocacy and support towards salt and hypertension reduction.

1.14 Theoretical Framework

The theoretical framework was inspired by ‘WHO’s SHAKE the Salt Habit’, which required identification of dietary sources of Na, determination of salt use behaviours and population salt intake, and development policy action to drive governmental efforts towards the reduction salt intake and hypertension [291]. The thesis followed the theoretical framework below.
Fig. 1.4 Theoretical framework for the thesis

Study 1. Major contributors of dietary salt to the diet in LMICs (Knowledge synthesis)

Study 2. Comparison of salt use behaviours among Ghanaians and South Africans

Study 5. Identification of population salt consumption in Ghana

Studies 3 & 4. Identification of hypertension prevalence and trends over time in Ghana and determinants thereof

Study 6. Participatory Action Research: Stakeholder engagement

Recommendations for Further Action
Advocacy for healthier food choices, voluntary salt reduction/policy
1.15 References


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285. The Ghana Health Sector 2006 Programme of Work


Chapter 2

Methodology

2.1 Introduction

As discussed in Chapter 1, hypertension is a major public health concern and a risk factor for developing CVDs [1, 2]. Dietary sources with high amounts of Na and low levels of K have been established as contributory factors to raised BP [3, 4]. To place this study in perspective and to provide a context, a systematic review was conducted on dietary sources of salt (Chapter 3). Systematic reviews are important in providing a strong evidence by compiling and synthesizing findings from various studies [5]. Our review followed the evidenced protocols of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines with a checklist and a flow diagram to guarantee reliability and uniformity [6, 7]. It was registered with International Prospective Register of Systematic Reviews (PROSPERO CRD42016038173) and rated highly on the National Health and Medical Research Council (NHMRC) recommendations [8, 9].

2.2 WHO-SAGE Study Design

Apart from the systematic literature review (Chapter 3), the entirety of this thesis was based on primary data collected during WHO-SAGE Ghana/SA Waves 1-3. Brief details of the study are provided within the published/submitted papers in chapters 4-8. Nonetheless, this chapter provides an in-depth description of the study design and scope, sample and sampling methods, instruments for data collection, validity of instruments, data collection techniques, ethical approval and data analysis for WHO-SAGE countries; Ghana and SA. Additionally, details of the nested sub study embedded with WHO-SAGE Ghana and SA W3 will be described.

The WHO-SAGE longitudinal study was created by the WHO Evidence, Measurement and Analysis unit (formerly the Multi-Country Studies unit) as part of an existing program of
work to collect comprehensive longitudinal data on the health and well-being of adult populations and the ageing process for the purposes of planning, policy and research.

A baseline cohort study created during the 2002–2004 World Health Survey (WHS) and implemented in about 70 countries formed the basis of WHO-SAGE study. The WHS study included six LMICs (i.e. China, Ghana, India, Mexico, Russia and SA), and data collected in these countries became what is known as WHO-SAGE W0 [10]. WHO-SAGE W1 was implemented from 2007 to 2010 as follow up to participants from W0. WHO-SAGE W2 follow up was implemented by the end of 2015. The most recent WHO-SAGE W3 follow-up was completed in 2018/19 in China, Ghana, India, Mexico and SA.

WHO-SAGE is a longitudinal cohort study that typically collects data on adults aged 18+y with about 70% of the participants being 50+y in a face-to-face interview that lasts 90-120 minutes. Nationally representative samples are drawn from the six LMICs and were followed up in each wave with new households and participants included in the subsequent data collections to account for participant attrition [11].

In terms of its scope, WHO-SAGE broadly incorporates the collection of data on household and related characteristics, risk factors and preventive health behaviours, subjective well-being and quality of life, as well as biomarkers among others. Participants also performed objective health tests such as grip strength, cognition tests and 4-metre timed walks.

2.3 Geodata

To assist in determining the sample, enumeration areas (EAs) were randomly selected using on Geo-coding/Global Positioning System (GPS) information based on the 2000 and 2001 census in Ghana and SA respectively. Geo-reference data which included Geographical Information System (GIS) coordinates of latitude and longitude gave the physical location of EAs and households selected for WHO-SAGE. Geographical data served several purposes, first, the accurate recording of coordinates of sampled households was necessary to assist with locating potential participants for subsequent rounds of the WHO-SAGE longitudinal data collection. Second, the EA and household GIS coordinates were stored in the WHO-SAGE database to be used for further spatial analyses of health and illness data.
Finally, the data may be linked with other data sources to measure distance between selected households and health-care facilities [12, 13].

2.4 Population

The total population was 24,658,823 in 2010 in Ghana, a figure representing an increase of 30.4 percent over the 2000 census population of 18,912,079. Ghana has a youthful population consisting of a large proportion of children under 15 years, and a small proportion of elderly persons (65 years and older). The distribution of the population by sex indicates that women (51.2%) are more than men and there are more people living in urban areas (50.9%) than rural areas. Akans are the predominant ethnic group in Ghana (47.5%), followed by the Mole Dagbani (16.6%), the Ewe (13.9%) and Ga-Dangme (7.4%). The Mande forms the smallest ethnic group (1.1%) in Ghana. Majority (74.1%) of the population 11 years and older is literate with variations in the levels of school attendance [14].

In the case of SA, 44, 819, 778 and 51, 770, 560 people were counted in 2001 and 2011, respectively. Relative to Census 2011, 25.2 million (48.7%) males counted were compared to 26.6 million (51.3%) females. Almost 29.6% of the population of SA is aged between 0-14 years and a further 28.9% is aged between 15 – 34 years, SA has five racial groups (Black African, Coloured, Indian or Asian, White and other) with Black African forming the majority of the population (41, 000, 938) and ‘other’ forming the least (280, 454). Additionally, the population is differed along 13 main ethnic lines with ‘Africans’ forming the majority (6, 855, 082) [15, 16]. For the purposes of WHO-SAGE, the target population was adults aged 18y+. Study sample was drawn from nationally representative frames using general population parameters.

2.5 Sample and Sampling Techniques

WHO-SAGE targets two adult populations: a large sample of persons aged 50y and older, and a smaller comparative sample of persons aged 18–49y; in line with the focus of the study. In all countries, households were used as primary sampling units and classified into one of these two mutually exclusive categories.: In the older households, all persons aged
50y and older, including spouses and siblings, were invited to participate. Proxy respondents were identified for participants who were unable to respond for themselves. A total of 250 and 396 EAs were randomly selected from Ghana and SA, respectively. Within each EA, 24 households were selected, comprising twenty 50+y households and four 18-49y households. The sample sizes varied over the three study waves based on feasibility and survey costs. Stratification for households was conducted according to region, provinces, population, and location (urban/rural) [12, 13]. For households that could not be accessed, a replacement was chosen. In Ghana, this was done by inviting all households within the EA that were originally not part of the study, but expressed willingness to participate, and randomly selecting those to participate. In SA, replacements for sample attrition used a systematic sampling approach to randomly select new households as previously described [17]. The sample sizes for Ghana and SA are given in Table 2.1:

Table 2. 1 Sample sizes for Ghana and SA (WHO-SAGE W1-3)

<table>
<thead>
<tr>
<th></th>
<th>SAGE W1</th>
<th>SAGE W2</th>
<th>SAGE W3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ghana</td>
<td>5,110</td>
<td>4,704</td>
<td>Pending</td>
</tr>
<tr>
<td>SA</td>
<td>4,223</td>
<td>3,153</td>
<td>Pending</td>
</tr>
</tbody>
</table>

WHO-SAGE Ghana, SA; sample sizes [18].

2.6 Nested Sub Study

WHO-SAGE Waves 2 and 3 included the nested sub study undertaken in Ghana and SA only. For the sub study, approximately one-fifth of the total number of EAs in each country, were randomly selected with the aim to recruit about 1200 participants who in addition to the main WHO-SAGE survey, provided urine samples. The sampling process for these participants was the same as those employed in the main survey. Details of the urine collections, handling, transportation, storage and analysis of the electrolytes have been described accordingly. For the purposes of this thesis, only participants recruited in the sub study during the WHO-SAGE W3 study were included. In total, 2,310 participants (Ghana, 1121; SA, 1189) provided urine samples.
2.7 Instruments for data collection

The SAGE survey is a composite document made up of three different questionnaires. Each questionnaire consists of several sections focusing on distinct facets of health and well-being among populations: 1) household questionnaire 2) individual questionnaire and (3 proxy participant questionnaire (Appendix B).

2.7.1 Household questionnaire
This questionnaire collected information about the household members, housing characteristics, assets, income and money transfers between household members and those outside the household. This data provides background characteristics for analyzing health outcomes. The household informant agreed to be interviewed through understanding and signing of a household consent form [12, 13].

2.7.2 Individual questionnaire
This questionnaire sought information about the individual’s sociodemographic characteristics, work history and benefits, health state and descriptions, anthropometrics, performance tests and biomarkers, risk factors and preventive health behaviours, chronic conditions and health services coverage, health care utilization, social cohesion, subjective well-being and quality of life, and impact of caregiving. The survey required the collection of health measurements and conducting health tests. All participants including those of the nested sub study responded to this survey.

2.7.2.1 Anthropometric measurement

The stadiometer, weighing scale and a flexible measuring tape were used to measure participants’ height, weight and waist/hip circumference respectively. In using the stadiometer, a firm flat floor close to a wall was selected. Participants were barefoot, stepped onto the base of the stadiometer with feet together, knees straight, back and head against the wall, looking straight ahead, chin tucked slightly to the chest and eyes same level as ears. The top of stadiometer was stretched to topmost point on the head with enough force to compress the hair. To weigh participants, the calibrated weighing scale was placed on a
flat, firm surface. Participants removed their shoes and any heavy accessories and stood on
the scale facing forward, arms placed at their side with palms facing inwards and not
holding onto anything. In terms of waist measurement, the measuring tape was placed
directly on the skin, or over no more than 1 layer of light clothing. The measurement was
taken round the body and halfway between the lowest rib and the top of your hipbone;
roughly in line with the belly button while the participant stood with feet together and arms
to the side with palms facing inwards. The same procedure for waist measurement was
applied to hip measurement, but with measuring tape going around the participants
buttocks [19].

2.7.2.2 BP measurement

Wrist worn Omron BP devices with positional sensors (Omron R6, Kyoto, Japan) were used
to measure BP. These devices satisfied the validation standards of the International Protocol
for SBP and DBP [20, 21]. Following 5 minutes of seated rest, three BP readings were
recorded on the left wrist (one-minute between each measurement) while the participant sat
with legs uncrossed and the wrist positioned precisely at the level of the heart. An average
of the second and third readings combined with self-reported use of hypertension
medication was used in categorizing hypertension status.

2.7.2.3 Urine collection

Screw cap bottles, funnels, measuring cylinders and 5ml tubes were used to collect 24hr
urine samples from nested sub study participants only. Fieldworkers handed a bag
containing 1) a 5L capacity screw cap bottle to store urine, 2) a 1L container with a wide
opening into which urine is voided with the use of a funnel, 3) 2L capacity screw cap bottle
for temporal collections of urine made away from home, 4) funnel to be used during urine
collection, kept inside a resealable plastic bag when not used, 5) plastic carrier bags for
transporting the equipment away from home and 6) an aide-memoire to help participants
to remember to collect their urine [22], selected participants for 24hr urine collection.
Fieldworkers explained urine collection requirements (both verbal and written) to participants and supervised the beginning and end of the collection periods. The instructions for the urine collection were that the participant should: 1) void the first urine of the in the morning of the start of the 24hr period, 2) record the time of the first urine collected, 3) collect all urine within the day and night into the 5L bottle including the first urine of the following morning, 3) only a participant’s urine should be collected into the bottles, 4) continue with urine collection if they missed a collection during the day, 5) take the 2L bottles out when they were leaving the house so all urine passed outside the house could be collected, 6) keep the urine bottles away from children, and at a cool place, 6) record time of the last collection, and 7) leave the urine bottles at a place that field workers can access to, after completion of urine collection [22].

The bottles contained 1g thymol which has the property to preserve urinary creatinine, Na and K concentrations for a period up to 5 days [23]. The urine bottles were picked up after 24hrs, the content thoroughly mixed up and volume measured. Volumes that were below 300ml were discarded [2, 25] and the participant was rescheduled. The urine was then aliquoted into 5ml tubes and transported in cold boxes and stored at -20 0C at the Noguchi Memorial Institute of Medical Research, University of Ghana (NMIMR-UG) and Global Clinical and Viral Laboratories and North-West University Centre of Excellence for Nutrition in SA. Aliquoted samples were given codes that corresponded with the identification numbers of the participants so that samples could be linked to the survey data of the participants.

2.7.3 Proxy Questionnaire
This questionnaire collected characteristics of participants who were incapacitated at the time of the survey, by requesting close relatives or care givers of the participant to provide participant’s information (Appendix B).

2.8 Data collection procedures and management
Prior to data collection for each wave of the study, the WHO-SAGE team in Geneva, visited Ghana and SA conducted training sessions for all fieldworkers including nurses and
technicians using standardized training and survey materials [11]. This training lasted 10 days on average, and taught fieldworkers the rudiments of survey, teamwork, general interviewer skills, ethics of research, how to use and complete WHO-SAGE survey, as well as collection and handling biological samples.

Fieldworkers conducted face to face interviews with participants, either in the households or participant’s workplaces. Field teams worked in groups of 3-5 interviewers with a supervisor. Households or participants that could not be reached at the time of data collection were replaced. For the first two waves of the study where data were collected on paper questionnaires, whilst CAPI was used to collect data during W2 and W3. Interviews were conducted in the participants’ home language while incomplete interviews rescheduled. During data collection, supervisors checked the quality and consistency of data collected, and took custody of the survey (W1), and urine samples (W2 and W3). Tracking sheets were used to track day to day progress of activities on the field, to serve as reminders of incomplete interviews, correct errors and deal with missing information. Supervisors were silent observers of the interviews - a responsibility that was considered a marker of quality assurance. During W1, completed questionnaires and tracking sheets were collected and posted to the principal investigator’s office while in W3, collected data, were accumulated on a local server and later transferred onto a centralized server. Urine samples were sent directly to the laboratories with tracking sheets to monitor samples sent and those received (nested sub study).

2.9 Study measures

One question investigated knowledge about salt and health - “Do you think that a high salt diet could cause a serious health problem?”- with answer options “yes” or “no”. Another investigated attitudes about salt- “How much salt do you think you consume?”- with answer options of “far too much”, “too much”, “just the right amount”, “too little”, “far too little”, “don’t know”, and “refused”. Three questions assessed salt use behaviours: (1) “Do you add salt to food at the table?“; (2) “In the food you eat at home, salt is added in cooking?“; and (3) “Do you do anything on a regular basis to control your salt or Na
intake?” with answer options “always”, “often”, “sometimes”, “rarely”, and “never” for items 1 and 2, and “yes”, “no”, “don’t know”, and “refused” for item 3. Likert type response scales were provided, but for analysis of responses to the salt use behaviour questions categories of “always” and “often” were combined to represent “frequent” use, whilst “rarely” and “sometimes” were combined to represent “infrequent” use.

Regarding national health insurance status, ‘voluntary’ contributors were defined as those individuals who were not captured by the health insurance scheme as public or civil service workers, while ‘mandatory’ contributors were employees from the public, civil and private sectors. For questions on alcohol and working status, responses were reduced to categorical variables.

Physical activity was measured using the International Physical Activity Questionnaire (IPAQ) through its long form questions. The level of physical activity was calculated based on type of activity, and number of days, hours and minutes participants engaged themselves in those activities per week. IPAQ has a high reliability and validity and has been used extensively in urban communities in both developed and developing countries [26]. BMI was calculated as the ratio of body weight in kilograms divided by the square of the height in metres.

A BP measurement was determined valid if: Systolic (SBP) > Diastolic (DBP); and SBP was between 80-270 mm Hg; and DBP was between 40-180 mm Hg; and SBP minus DBP (Pulse Pressure, PP) > 13mm Hg. Hypertension classification was determined according to the European Society for Hypertension Guidelines (2018), that is, systolic ≥140 and/or diastolic ≥90 mm Hg [27]. Hypertension status was classified as self-reported treatment or having a measured BP ≥ 140/90mm Hg, while hypertension awareness was based on self-reported previous diagnosis of hypertension in those with BP ≥ 140/90mm Hg. Hypertension treatment was determined as self-reported medication use for hypertension in at least two weeks prior to data collection. Hypertension control was assessed as those who self-reported antihypertensive medication use within the last two weeks and had a BP
measurement of less than 140/90 mm Hg. PP was measured as difference between SBP and DBP, representing the force that the heart generates each time it contracts.

Sodium and K concentrations were determined by indirect ion-specific electrodes, Cr concentration by using the Jaffe reaction colorimetric method iodine by Sandell-Kolthoff method with ammonium persulfate digestion and microplate [23]. Sodium (mmol/l) in the 24 h urine sample was converted to salt (g/d) using the formula: Na mmol/l x 24 h volume (litres) x 23.1 (molecular weight of Na)/390 (390 mg Na per 1 g NaCl (salt). From this variable, participants were categorized as having low (<5 g/day), medium (5-9 g/day) or high (>9 g/day) salt intake. K (mmol/l) in the 24 h urine sample was converted to K (mmol/d) using the formula: K (mmol/l) x 24 h volume (litres) [28].

2.10 Ethical considerations

The study complied with the standards of the Helsinki Declaration [29] and approved by WHO Research Ethics Review Committee [RPC149] (appendix C). Country specific ethics approval was granted from the University of Ghana (MS-Et/M.03-P 3.1/2005-2006), (Appendix D), North-West University and University of Witwatersrand (SA). Only participants that reviewed and signed informed consent forms could participate in the study (Appendix B).

2.11 Data analysis

All statistical analyses are described in the respective chapters.

2.12 References


Chapter 3

Dietary Sources of Salt in Low- and Middle-Income Countries: A Systematic Literature Review

This chapter describes a systematic literature review conducted to ascertain the sources of food that contribute most salt to the diet in LMICs. Urbanization and population growth coupled with the nutrition transition occurring in LMICs is transforming lifestyles and dietary patterns. As such, there has been a shift from the consumption of traditional staples to an increased reliance on energy dense foods that are high in salt. This chapter evaluates and synthesizes the evidence gathered from published literature and makes inferences.

The most of this chapter is the substantive content of the published work:

Abstract

Rapid urbanization in low- and middle-income countries (LMICs) is transforming dietary patterns from reliance on traditional staples to increased consumption of energy-dense foods high in saturated fats, trans fats, sugars, and salt. A systematic literature review was conducted to determine major food sources of salt in LMICs that could be targeted in strategies to lower population salt intake. Articles were sourced using Medline, Web of Science, Scopus, and grey literature. Inclusion criteria were reported dietary intake of Na/salt using dietary assessment methods and food composition tables and/or laboratory analysis of salt content of specific foods in populations in countries defined as low or middle income (LMIC) according to World Bank criteria. Of the 3207 records retrieved, 15 studies conducted in 12 LMICs from diverse geographical regions met the eligibility criteria. The major sources of dietary salt were breads, meat and meat products, bakery products, instant noodles, salted preserved foods, milk and dairy products, and bouillon cubes. Identification of foods that contribute to salt intake in LMICs allows for development of multi-faceted approaches to salt reduction that include consumer education, accompanied by product reformulation.

3.1 Introduction

Cardiovascular diseases (CVDs) are the leading cause of death worldwide [1], with hypertension accounting for more than 50% of premature deaths [2]. Globally, the prevalence of hypertension has been rising from a figure of 25% reported in 2000 [3] to 40% reported by others in 2008[4]. Hypertension is the leading single risk factor contributing to overall Global Burden of Disease [2] through its association with cardiovascular disease. Low-and middle-income countries (LMICs) already share the highest prevalence of hypertension [5], with predictions that three quarters of the world’s hypertensive population will be found in these countries within the next 10y [3]. This may be in part due to the larger population sizes in LMICs compared to high-income countries, but also because of the inability of their health care systems to cope with the management of chronic
diseases. This results in large numbers of people with undiagnosed, untreated, and uncontrolled hypertension [6]. LMICs are currently facing an unprecedented hypertension burden [6]. The past four decades have seen a shift in the highest blood pressure (BP) levels from high-income countries to LMICs, particularly in some South Asian and sub-Saharan African countries [7] where more than a third of adults report being hypertensive [6]. Additionally, there is low awareness, treatment, and control measures for hypertension in LMICs [8], rendering current practices to reduce hypertension ineffective [9,10]. Ultimately, the worsening situation of hypertension together with increased prevalence of cancers, diabetes, and chronic respiratory diseases have culminated in nearly 80% of all deaths from NCDs occurring in LMICs [11]. The nutrition transition in many LMICs is occurring due to the rapid urbanization which has led to widespread availability of energy-dense foods that are high in saturated fats, trans fats, sugars, and salt. This has resulted in a shift in dietary patterns from a reliance on traditional staples such as maize and sorghum to more processed foods [12]. At the same time, food insecurity remains a challenge in LMICs [13]. Preserving food using traditional methods (e.g., salting) is important in ensuring food availability and addressing hunger in many communities [14,15]. Further, limited water supplies [16] have exposed populations to unhealthy water sources which often contain toxins or unacceptable levels of nutrients [17,18]. A mean Na concentration of about 700 mg/L (with extremes exceeding 1500 mg/L) was found in drinking water in coastal areas of Bangladesh [19] contributing to the overall daily Na consumption of people living along the coast. With this, the WHO's recommended daily limit of 5 g salt [20] can easily be exceeded by just drinking 2–3 L of water in some countries. There is compelling evidence from epidemiological, clinical, and experimental studies showing a positive and direct relationship between salt consumption and BP. It is widely accepted that high intakes of salt in food (beyond the WHO's recommended level of 5 g salt or 2 g Na/day) and in water (>0.2 g Na/L) are major risk factors for hypertension [20,21], heart disease, and stroke [22]. Sodium is an important nutrient required by the body to ensure ion balance, maintenance of plasma volume, and transmission of nerve impulses [23]; however, when in excess, has been implicated in the development of kidney disease, gastric cancer, and hypertension [24,25]. Lower levels of Na
(<3 g/d) have also been identified to be associated with higher risk of death and cardiovascular events [26]. Several prospective cohort studies have indicated a U-shaped relationship between salt consumption and cardiovascular disease or mortality, with increased risk at both high- and low-intake extremes [27–30]. In comparison with a moderate consumption of salt, observational data demonstrate that very high intakes (>6 g Na/day, representing only 10% of the population studied) are associated with an excessive risk of cardiovascular events and death, but only in the case of those with hypertension. This study also reported associations between low salt intakes and increased risk of cardiovascular events and death in both hypertensives and normotensives [31]. While the optimal lowest intake of salt is still being debated, there is no question that in most countries, population-level estimates of salt far exceed the commendation of a maximum 5g/day, thus, necessitating salt reduction strategies [20]. In 2004, the WHO released its “Global Strategy on Diet, Physical Activity and Health” that was adopted by the World Health Assembly and which called upon all governments and stakeholders to work towards improving the healthfulness of diets [32]. More recently, WHO member states have agreed to work towards voluntary targets to reduce NCDs by 25% by 2025, with one of the nine global targets being a reduction in population salt intake by a relative 30% [22]. In order to develop national policies and strategies to lower population-level salt intake in LMICs, it is necessary to understand the main dietary sources of salt. This information is required to assist governments to enact policies and programs, and to concentrate on particular food items that are of relative importance to excessive salt consumption in LMICs. The aim of this systematic literature review is to identify the major food sources that contribute to salt consumption in populations in LMICs.

3.2. Methods

A literature search was conducted in March 2017 using the Medline, Web of Science, and Scopus databases. Hand searching of the reference lists was performed from articles retrieved from these databases. Grey literature was also searched by visiting institution and government websites and other sources. Data collected were synthesized according to the
Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [33] (Figure 3.1). The research question investigated was: “What are the dietary sources of salt in LMICs?” Search terms are listed in Table 3.1. Outcome measures include dietary sources of Na/salt. Only articles reported in English were included. All countries in the LMIC bracket were listed among the search terms. Low-income economies were defined as those with a gross national income (GNI) per capita, calculated using the World Bank Atlas method, of $995 or less in 2017; lower middle-income economies were those with a GNI per capita between $996 and $3895; and upper middle-income economies were those with a GNI per capita between $3896 and $12,055 [34]. The search was restricted to articles published from 1960 onwards.
<table>
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<th>Searches</th>
<th>Search Terms</th>
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<td>Medline</td>
<td>&quot;source of salt&quot; OR &quot;dietary salt&quot; OR &quot;discretionary salt&quot; OR &quot;salt intake&quot; OR &quot;salt in food&quot; OR &quot;salt added at the table&quot; OR &quot;dietary sources of sodium&quot; AND &quot;Algeria&quot; OR &quot;Angola&quot; OR &quot;Benin&quot; OR &quot;Botswana&quot; OR &quot;Burkina Faso&quot; OR &quot;Burundi&quot; OR &quot;Cameroon&quot; OR &quot;Cape Verde&quot; OR &quot;Central African Republic&quot; OR &quot;Chad&quot; OR &quot;Democratic Republic of Congo&quot; OR &quot;Equatorial Guinea&quot; OR &quot;Ethiopia&quot; OR &quot;Gabon&quot; OR &quot;Gambia&quot; OR &quot;Ghana&quot; OR &quot;Guinea&quot; OR &quot;Guyana&quot; OR &quot;Haiti&quot; OR &quot;Indonesia&quot; OR &quot;Iran&quot; OR &quot;Iraq&quot; OR &quot;Italy&quot; OR &quot;Jamaica&quot; OR &quot;Jordan&quot; OR &quot;Kenya&quot; OR &quot;Libya&quot; OR &quot;Moldova&quot; OR &quot;Montenegro&quot; OR &quot;Myanmar&quot; OR &quot;Namibia&quot; OR &quot;Nepal&quot; OR &quot;Pakistan&quot; OR &quot;Peru&quot; OR &quot;Poland&quot; OR &quot;Portugal&quot; OR &quot;Romania&quot; OR &quot;Russia&quot; OR &quot;Sao Tome and Principe&quot; OR &quot;Senegal&quot; OR &quot;Sierra Leone&quot; OR &quot;Somalia&quot; OR &quot;South Africa&quot; OR &quot;South Sudan&quot; OR &quot;St. Lucia&quot; OR &quot;St. Vincent and the Grenadines&quot; OR &quot;Suriname&quot; OR &quot;Swaziland&quot; OR &quot;Tanzania&quot; OR &quot;Thailand&quot; OR &quot;Timor-Leste&quot; OR &quot;Tunisia&quot; OR &quot;Turkey&quot; OR &quot;Ukraine&quot; OR &quot;United Arab Emirates&quot; OR &quot;United Kingdom&quot; OR &quot;United States&quot; OR &quot;Vietnam&quot; OR &quot;Yemen&quot; OR &quot;Zimbabwe&quot;</td>
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<td>Web of Science</td>
<td>Bissau&quot; OR &quot;Kenya&quot; OR &quot;Lesotho&quot; OR &quot;Liberia&quot; OR &quot;Madagascar&quot; OR &quot;Malawi&quot; OR &quot;Mauritius&quot; OR &quot;Mozambique&quot; OR &quot;Namibia&quot; OR &quot;Nigeria&quot; OR &quot;Reunion&quot; OR &quot;Rwanda&quot; OR &quot;Sao Tome and Principe&quot; OR &quot;Senegal&quot; OR &quot;Seychelles&quot; OR &quot;Sierra Leone&quot; OR &quot;South Africa&quot; OR &quot;Swaziland&quot; OR &quot;Tanzania&quot; OR &quot;Togo&quot; OR &quot;Uganda&quot; OR &quot;Zambia&quot; OR &quot;Zimbabwe&quot; OR &quot;Albania&quot; OR &quot;American Samoa&quot; OR &quot;Armenia&quot; OR &quot;Azerbaijan&quot; OR &quot;Bangladesh&quot; OR &quot;Belarus&quot; OR &quot;Belize&quot; OR &quot;Bhutan&quot; OR &quot;Bolivia&quot; OR &quot;Bosnia and Herzegovina&quot; OR &quot;Brazil&quot; OR &quot;Bulgaria&quot; OR &quot;Cambodia&quot; OR &quot;China&quot; OR &quot;Colombia&quot; OR &quot;Comoros&quot; OR &quot;Costa Rica&quot; OR &quot;Cuba&quot; OR &quot;Macedonia&quot; OR &quot;Malaysia&quot; OR &quot;Maldives&quot; OR &quot; Marshall Islands&quot; OR &quot;Mexico&quot; OR &quot;Micronesia, Fed. Sts.&quot; OR &quot;Moldova&quot; OR &quot;Mongolia&quot; OR &quot;Montenegro&quot; OR &quot;Myanmar&quot; OR &quot;Nepal&quot; OR &quot;Nicaragua&quot; OR &quot;Pakistan&quot; OR &quot;Palau&quot; OR &quot;Panama&quot; OR &quot;Papua New Guinea&quot; OR &quot;Paraguay&quot; OR &quot;Peru&quot; OR &quot;Philippines&quot; OR &quot;Romania&quot; OR &quot;Rwanda&quot; OR &quot;Samoa&quot; OR &quot;Dominica&quot; OR &quot;Dominican Republic&quot; OR &quot;Ecuador&quot; OR &quot;Serbia&quot; OR &quot;El Salvador&quot; OR &quot;Solomon Islands&quot; OR &quot;Fiji&quot; OR &quot;Sri Lanka&quot; OR &quot;St. Lucia&quot; OR &quot;Georgia&quot; OR &quot;St. Vincent and the Grenadines&quot; OR &quot;Grenada&quot; OR &quot;Suriname&quot; OR &quot;Guatemala&quot; OR &quot;Syria&quot; OR &quot;Tajikistan&quot; OR &quot;Guyana&quot; OR &quot;Haiti&quot; OR &quot;Thailand&quot; OR &quot;Honduras&quot; OR &quot;Timor-Leste&quot; OR &quot;India&quot; OR &quot;Indonesia&quot; OR &quot;Tonga&quot; OR &quot;Iran&quot; OR &quot;Iraq&quot; OR &quot;Turkey&quot; OR &quot;Jamaica&quot; OR &quot;Turkmenistan&quot; OR &quot;Jordan&quot; OR &quot;Tuvalu&quot; OR &quot;Kazakhstan&quot; OR &quot;Ukraine&quot; OR &quot;Kiribati&quot; OR &quot;Uzbekistan&quot; OR &quot;Korea, Dem. People's Rep.&quot; OR &quot;Vanuatu&quot; OR &quot;Kosovo&quot; OR &quot;Vietnam&quot; OR &quot;Kyrgyz Republic&quot; OR &quot;West Bank and Gaza&quot; OR &quot;Lao PDR&quot; OR &quot;Yemen&quot; OR &quot;Lebanon&quot;</td>
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Records identified through database searching (n=3184)  
Grey Literature (n=23)  
Duplicates excluded (n=197)  
Records screened based on titles (n=3010)  
Records excluded based on titles (n=2833)  
Abstract screened (n=177)  
Abstract excluded (n=143)  
Full-text articles assessed for eligibility (n=34)  
Full text articles excluded (n=19)  
11 did not report Na content of specific foods  
4 full texts could not be retrieved  
2 were on apparent consumption data  
1 was a methodology paper  
1 compared Na content on food labels with established maximum levels  
Articles included in qualitative analysis (n=15)  

Figure 3. 1 Flow Diagram
Data extraction was completed by the lead author (EM) and reviewed by the second author (KC). Endnote X4 (Clarivate Analytics, Philadelphia, PA, USA) was used to manage the citations. Each article was ranked for level of evidence using the National Health and Medical Research Council (NHMRC) recommendations [35]. A narrative synthesis of the studies was completed because of the heterogeneity in reporting outcomes of the studies. In this literature review, Na and salt were used interchangeably. Studies were included if a study (a) reported actual quantities of Na/salt in foods (b) data were collected from food diaries, diet recalls, food frequency tables and (c) laboratory analysis of salt content in food. Data were extracted by first reviewing the title and selecting abstracts of those with relevant titles. If the abstract met the inclusion criteria, the full article was retrieved (Figure 3.1). Studies were summarized according to descriptive characteristics, including the region, country, data collection period, study emphasis, and the study design. Each paper was categorized also by the author, population, outcome measured, method of measurement, and the results. Quality rating was conducted using appraisal tools for cross-sectional studies for nine articles that utilized a human population [36] (Appendix A). This systematic review was registered with the International Prospective Register of Systematic Reviews (Prospero CRD42016038173).

3.3 Result

Our search of data bases and additional records yielded 3207 titles. One-hundred-and-seventy-seven abstracts (23 hand-searched) were retrieved after duplicates and irrelevant papers were excluded, thereafter resulting in 34 full papers being assessed for eligibility and inclusion. Of these 34 articles, 15 were included in the final review. Reports from the country level WHO Stepwise Surveillance surveys were hand-searched but did not yield relevant information. Figure 3.1 shows the PRISMA flow diagram providing details of the search and included studies. Of the final included articles grouped according to WHO-defined geographical regions [37], the greatest number of articles (i.e., four each) were from Africa and the Western Pacific (though in the Western Pacific region, all the articles came from China), whereas the least number of the articles (i.e., one) came from European countries.
Fifteen of the included studies were conducted in 12 countries and most of them had been published within the last two decades (1991–2016). Six of the articles did not report data collection periods. With the exception of one randomized controlled trial, all other studies were cross-sectional and descriptive in design and concentrated on dietary behavior and product reformulation. Analytical values for the salt content of bread were reported in five articles (Table 3.1). Zibaeenezhad et al. [38] included the highest number of samples of bread that were examined, whereas Ferrante et al. [39] recorded the greatest number of bakeries that were sampled within one study. For studies that included samples of bread from different suburbs and locations, salt content varied depending on the municipality and producer. The highest salt content found in bread was 1.80g/100g in Nigeria [40]. The average salt content in bread from all articles was more than the voluntary targets and recommended quantities in other countries (380–400 mg Na per 100 g bread) [41–43]. One study from Ferrante et al. [39] analyzed salt content in French bread, croissants, and cookies and crackers using dietary recall and additionally used biochemical analysis for French bread. Results from the two methods used for French bread indicated an underestimation of salt use with the dietary recall. Financial constraints did not permit chemical analysis of the other food items. There were three articles that reported salt content of additional foods other than bread, including preserved fish, cookies, crackers, as well as water (Table 3.2) and seven articles assessed total dietary salt intake (Table 3.3). Two of the included articles [44,45] investigated children’s’ dietary salt intake. Four of the articles that measured dietary intake also included biomarkers of participants’ 24hr urinary Na excretion [46–49]. The major sources of dietary salt were breads, meat and meat products, bakery products, noodles, salted preserved foods, milk and dairy products, and bouillon cubes. Additionally, some articles reported that a high amount of salt in the local diet came from discretionary salt [45,49,50], but this was not consistently measured.
<table>
<thead>
<tr>
<th>Reference</th>
<th>Population</th>
<th>Outcome measured</th>
<th>Method of measurement</th>
<th>Results</th>
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<tbody>
<tr>
<td>Silva et al., 2015 [43]</td>
<td>All bakeries (n=17) situated in Maputo city that were listed in the Mozambican Yellow Pages were included.</td>
<td>Na content in bread.</td>
<td>Flame photometry.</td>
<td>Mean Na content of bread was 450 mg/100 g, ranging between 255 mg/100g and 638 mg/100g, with no significant differences between bakeries and traditional markets. Most samples (88 %) did not meet the regulation for SA. Mean Na &gt; a, b and c.</td>
</tr>
<tr>
<td>Nwanguma &amp; Okorie, 2013 [39]</td>
<td>Retail samples of 100 brands of white bread made from wheat flour, representing the major brands were purchased from 10 standard retail outlets in Nsukka and Enugu towns, both in Enugu State in South-Eastern Nigeria.</td>
<td>Na content in bread.</td>
<td>Flame photometry.</td>
<td>Na ranged from 396g to 1332g/100g. Mean= 544mg/100g. Mean Na &gt; a, b, c and d.</td>
</tr>
<tr>
<td>Hussain &amp; Takruri, 2016 [44]</td>
<td>68 samples of seven types of bread were collected from 13 different bakeries in the city of Amman.</td>
<td>Na content in bread.</td>
<td>Flame photometry.</td>
<td>Mean Na content = 476 ± 84g/100g ranging between 168 ± 20g for White Arabic bread* to 824 ± 76g/100g for Shrak bread*. Mean Na &gt; a, b and c.</td>
</tr>
<tr>
<td>Reference</td>
<td>Population</td>
<td>Outcome measured</td>
<td>Method of measurement</td>
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<tr>
<td>Zibaeenezhad et al., 2010 [37]</td>
<td>204 bakeries in districts of Shiraz city in Iran: 408 bread samples were collected representing from bakeries for measuring their salt content 6 different kinds of bread.</td>
<td>Na content in bread.</td>
<td>Laboratory testing of salt percentage in bread as outlined by Iran’s Organization for Standards and Industrial Investigations [45].</td>
<td>Mean Na = 524g/100g ranging of 0-1400g/100g bread. Mean Na &gt; a, b, c and d.</td>
</tr>
<tr>
<td>Vukić et al., 2013 [46]</td>
<td>12 samples of bread purchased in stores from the 3 municipalities: Bijeljina, Zvornik and East Sarajevo in Bosnia. In each municipality 8 samples were randomly selected.</td>
<td>Na content in bread.</td>
<td>Atomic absorption spectrophotometry (AAS) using an instrument VARIAN SpectrAA-10.</td>
<td>Mean Na = 405 ± 177mg/100 g, 489 ± 174mg/100g and 673 ± 119mg/100g for East Sarajevo, Bijeljina and Zvornik respectively. Bread samples from East Sarajevo, mean Na &gt; a and b. Bread samples from East Bijeljina, mean Na &gt; a, b and c. Bread samples from East Zvornik, mean Na &gt; a, b, c, d and e.</td>
</tr>
</tbody>
</table>

White Arabic and shrak bread are bread types in Amman.

a. > 380g/100g - maximum level of Na in bread established by the South African Government; effective June 2019 [40].

b. > 400mg/100g - maximum level of Na in bread recommended by the Government of Australia [41, 42].

c. > 450mg/100g - maximum level of Na in bread recommended by the National Heart Foundation of New Zealand [41].
d. > 490mg/100g - Level of Na that is required by the Finish Government for the designation of ‘highly salty’ on a label [47].

e > 550mg/100g - maximum level of Na in bread established by the Portuguese Government [48].
### Table 3. Summary table of studies that assessed consumption of salt from specific foods and water

<table>
<thead>
<tr>
<th>Reference</th>
<th>Population</th>
<th>Outcome measured</th>
<th>Method of measurement</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kerry et al., 2005</td>
<td>12 villages (6 rural, 6 semi-urban were chosen in Ghana. Between 95 and 250 subjects aged 40–75 years from each village, for a total = 1,896, selected by stratified random sampling from a census of all inhabitants of the village.</td>
<td>Frequency of consumption of high salt foods.</td>
<td>FFQ asked about the consumption of five salty foods: koobi, momoni, kako (all salted fish), salted pig's feet and salted beef. Also questioned the use discretionary salt, stock cubes or monosodium glutamate (MSG).</td>
<td>92% reported eating salted fish. While salted meat (pig's feet and beef) was eaten more often by semi-urban villagers, salted fish was eaten more often by rural villagers. Majority of the respondents (98%) frequently added salt to food in cooking.</td>
</tr>
<tr>
<td>Ferrante et al., 2011</td>
<td>25 000 bakeries countrywide affiliated to Argentinean Federation of Bakeries.</td>
<td>Na content in bakery products.</td>
<td>Dietary recall and Flame photometry.</td>
<td>Self-reported (using food composition table) mean Na contents: French bread = 1440mg ranging 800-3200mg/100g, croissants and cookies = 1440mg ranging 800-2800mg/100g, crackers = 2320mg ranging 1760-4000mg/100g, and flat rounded crackers = 1760mg ranging 960-2720mg/100g. Chemical analysis of French bread showed a mean Na concentration of 1600mg ranging from 1120-2400mg/100g.</td>
</tr>
<tr>
<td>Khan et al., 2011</td>
<td>343 pregnant Dacope women from Bangladesh recruited for a pilot phase of a larger study.</td>
<td>Na intake from drinking water sources.</td>
<td>Indirect estimates of individual salinity intake from groundwater and river water, determined using salinity data for 1998-2000; Centre for Environment and Geographic Information System (CEGIS) in Bangladesh.</td>
<td>Na from drinking water = 2064mg/day during the dry season (depending on the water source) and 480mg/day during the monsoon season assuming a conservative water intake of 2 L/day/person.</td>
</tr>
</tbody>
</table>

Note: 5g/d salt = 2000mg Na
<table>
<thead>
<tr>
<th>Reference</th>
<th>Population</th>
<th>Outcome measured</th>
<th>Method of measurement</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charlton et al., 2005 [54]</td>
<td>300 men and women from three different ethnic groups (black, mixed ancestry, and white), aged 20 to 65 y, conveniently sampled from place of work, Cape Town City Council, SA. Equal numbers of hypertensive (BP ≥ 140/90 mm Hg and/or on antihypertensive medication) and normotensive (blood pressure &lt; 140/90 mm Hg) men and women were planned (n = 150/group, 50 from each ethnic group).</td>
<td>Dietary intake of Na.</td>
<td>Interviewer-administered 3-repeated 24-h recalls. Standard household measuring utensils, rulers and food photographs of typical South African foods [57] used to quantify food portion sizes. The average daily nutrient intake calculated using Foodfinder III computerized dietary assessment program, based on Medical Research Council Food Composition Tables [58].</td>
<td>In all three subsamples, cereals were the main contributor to total reported dietary Na intake (45.9% to 48.6%), followed by meat and meat products (20.3% to 23.6%) and milk and dairy products (6.3% to 8.1%). In all groups, bread was the major source of dietary Na (25.2% to 40.5%).</td>
</tr>
<tr>
<td>Liu et al., 2014 [53]</td>
<td>726 Chinese postmenopausal women who attended a screening visit for a randomized controlled trial testing the effect of soy products supplementation on BP were conveniently sampled.</td>
<td>Dietary intake of food substances from which Na content was determined.</td>
<td>3-day food records questionnaire was used to estimate dietary nutrients intake. Food items were those most frequently consumed based on previous local surveys [59, 60]. Subjects received a 30-min training on estimation of food amounts, portion and utensil sizes. Dietary Major sources of non-discretionary salt include soup (21.6%), rice and noodles (13.5%), baked cereals (12.3%), salted/preserved foods (10.8%), Chinese dim sum (10.2%) and sea foods (10.1%) of the total salt intake.</td>
<td></td>
</tr>
</tbody>
</table>

Table 3. 4 Summary table of studies that assessed total salt intake using dietary assessment methods
<table>
<thead>
<tr>
<th>Reference</th>
<th>Population</th>
<th>Outcome measured</th>
<th>Method of measurement</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zhao et al., 2015 [50]</td>
<td>903 families were conveniently sampled for the study. 2952 participants were recruited from families in urban (Xicheng District) and suburban (Huairou District) Beijing. Study families were recruited through public primary and junior high schools. Eligible families were those with a child from the enrolled schools.</td>
<td>Dietary salt intake and sources of salt in the diet.</td>
<td>Questionnaire; a simplified “one-week salt estimation method” was designed to measure each family member’s daily salt intake and determine the sources of salt in the diet. This method estimates salt intake from three sources: household cooking, processed food, and cafeterias or restaurants. The methodology is previously published [63].</td>
<td>Nutrients were calculated based on the China Food Composition Table and local Na database [61, 62]. Total Na intake was calculated by summing the estimates from all contributory food items or groups. Soy sauce, vinegar, other sauces and MSG contributed 47%, 34%, 12% and 7% to total Na intake. The mean Na intake was 5360 (SD 3320) mg/day. Adults consumed more Na 6080(SD 3640) mg/day than children and adolescents 4400 (SD 2480) mg/day and senior citizens 4080 (SD 1920) mg/d.</td>
</tr>
<tr>
<td>Health Promotion Board, Singapore, 2011 [64]</td>
<td>National Nutrition Survey 2010 comprised 739 subjects aged 18-69 years conveniently sampled.</td>
<td>Na content in selected foods.</td>
<td>Face-to-face interviews were conducted where dietary practices and food frequency questionnaires were administered. Nutrients and various</td>
<td>Fish balls, fish cakes, breads and noodles were estimated to contribute 37% of the population’s salt intake. Daily salt intake was 3320mg/day.</td>
</tr>
<tr>
<td>Reference</td>
<td>Population</td>
<td>Outcome measured</td>
<td>Method of measurement</td>
<td>Results</td>
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<tr>
<td>Du et al., 2014 [65]</td>
<td>Secondary data from China Health and Nutrition Survey (1991-2009) comprising 16,869 adults aged 20–60y was used.</td>
<td>Na intake from foods and condiments</td>
<td>Three consecutive 24-h dietary recalls in combination with weighing methods. All foods and condiments recorded and measured. Na intake (ie, Na from all foods and condiments) were based on their compositions in the Chinese food-composition table.</td>
<td>Most of the salt (60%) came from table salt and sauces.</td>
</tr>
<tr>
<td>de Moura Souza, 2013 [49]</td>
<td>Nationwide dietary survey. Food consumption of a representative sample of the Brazilian population 10 years of age or older (n = 34,003).</td>
<td>Na content in foods and beverages.</td>
<td>24hr dietary recall using the nutrition data system for Research software version 2008, the Brazilian Food Composition Table</td>
<td>Foods with high Na densities (&gt;600mg/100g) included salty preserved meats (997 mg/100 g), processed meats (974 mg/100 g), cheeses (883 mg/100 g), and bread (741 mg/100 g). The major source of dietary Na was added salt, followed by soy sauce, processed foods, and MSG. The average soy sauce intake was 6.9 g/d, accounting for 8.5% of total Na intake. The average processed food intake was 244.7 g/d, which represented 20.8% of all food consumed and accounted for 6.8% of total Na intake. The average MSG intake was 1.5 g/d, accounting for 3.4% of total Na intake.</td>
</tr>
<tr>
<td>Reference</td>
<td>Population</td>
<td>Outcome measured</td>
<td>Method of measurement</td>
<td>Results</td>
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<tr>
<td>Anderson et al., 2010 [55]</td>
<td>Participants were 4,680 women and men aged 40 to 59 years, recruited by stratified random sampling from 17 diverse populations—community-based or workplace-based—in Japan (four samples), People's Republic of China (three rural samples), the United Kingdom (two samples), the United States (eight samples). Na intake was calculated by summing estimates from all contributory food sources, including foods and beverages, ingested at home or away from home.</td>
<td>Na intake was calculated by summing estimates from all contributory food sources, including foods and beverages, ingested at home or away from home.</td>
<td>24-hour dietary recall. Na content of each food item was determined using the enhanced national food database for each country.</td>
<td>For China, mean Na intake = 3,990 ± 1943 mg/person/day; Soy sauce = 256mg/person/day, mustard, turnip greens, and cabbage = 143mg/person/day, sodium bicarbonate and sodium carbonate (tenderizers) = 98mg/person/day and noodles was 89mg/person/day. Japan, mean Na intake = 4651 ±1279, United Kingdom mean Na intake = 3406±1162 and United</td>
</tr>
<tr>
<td>Reference</td>
<td>Population</td>
<td>Outcome measured</td>
<td>Method of measurement</td>
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<tr>
<td></td>
<td></td>
<td>States mean Na</td>
<td></td>
<td>= 3660±1343.</td>
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</tbody>
</table>

Note: 5g/d salt = 2000mg N
3.4 Discussion

To reduce population salt intake, the WHO “SHAKE the Salt” framework strongly emphasizes a need to identify major sources of salt in the diet and to embark on strategies that include product reformulation, taxation, nutrition labelling, and nutrition education [69]. The current review has identified bread as the major food source that provided the highest amounts of salt to the diets of populations in 12 LMICs. Meat and meat products, salted meat and fish, sauces, spreads, bouillon cubes, pizza, sandwiches, seafood, and ground or river water were also identified as major contributors to non-discretionary salt intake. Contribution of each of these foods differs by cuisine of the country, for example among Asian countries, sauces and MSG are prevalent [45,50,66], whereas in Africa and Latin America it is bakery, meat, and dairy products [40,44,49]. The average Na content for bread was above 400 mg per 100 g bread, which exceeded the generally accepted target for salt content of bread [41–43,70]. Similarly, in high-income countries such as Australia, some loaves provide more than 25% of the maximum daily recommended intake of salt in bread in just two slices [71], with bread and bread rolls contributing 25% of total salt provided by processed foods [72]. The consumption of bread has increased in LMICs [73] due to the decline in traditional staples such as maize, millet, and sorghum to the rise in wheat [74]. In India, the production of wheat increased from 75.81 million MT in 2007 to 94.88 million MT in 2012 [75], while Pakistan experienced a 3.2% increase between 2012 and 2013 [76]. Food preferences have changed, and this has altered the consumption of traditional staples. Relatively, there has been a global shift in dietary patterns from the reliance on traditional staples to processed foods due to the increased production of processed foods and changing lifestyles [20]. The Food and Agriculture Organization predicts that with the rise in income levels, preference for wheat products will increasingly overshadow traditional coarse grains [77]. In many LMICs, wheat is gradually replacing roots and tubers [78]. Furthermore, rapid urbanization in LMICs is changing diets such that “fast foods” (ready-to-eat), which typically contain excess salt, have replaced core staple plant-based foods, thereby increasing the demand for processed foods [79]. Other reasons for shifts to a greater reliance on
processed foods may be related to an increase in the number of women in the workforce, which has affected roles within the household related to food preparation [80]. The rising trend of eating away from home or eating prepared food away from home has contributed to the increased consumption of bakery products [81,82] in urban settings. Bread has virtually become a staple food [83], and which for many, forms the basis of breakfast, lunch, and dinner. For example, in some parts of the Democratic Republic Congo, bread has substituted cassava, the traditional starchy staple used in preparing “foufou” (dough made from boiled and ground plantain or cassava) [84]. Similarly, bread intake is higher than traditional staples in southern Mozambique [85,86] and is widely eaten as a snack or as a complete meal in Nigeria [87]. Bread is easily accessible from stores and vendors, and more convenient than traditional cereal and root staples, both of which require time and effort for preparation before consumption. In the Seychelles, there has been a decreased consumption of the traditional staple (fish) as a result of increased intake of meat, poultry, processed meat, and snacks [88]. There have been major increases in meat (i.e. beef, pork, and poultry) in LMICs [89, 90], including processed meat that is high in salt [91, 92]. Increased consumption of processed meat products has the potential risk of coronary heart disease, type-2 diabetes, and colorectal cancer [93, 94]. In Australia, processed meat contributed 10% of daily Na intake [95] and is a major contributor to salt intake in the United Kingdom [96]. Bacon for example, contains more than twenty times the quantity of salt compared to fresh pork of the same weight [97]. As countries are becoming more economically wealthy, there has been an increased demand for animal source products with livestock being one of the fastest growing agricultural subsectors in LMICs [98], and accompanying advancement in food technology in these countries resulting in increased availability of processed animal products. These processed animal products may be contributing to the increase in salt intake within LMIC populations. A potential strategy to reduce salt intake would be to reduce processed meat intake. This would have the additional benefit of reducing climate change issues such as high green-house gas emissions from cattle and diverting agricultural land use from human consumption to animal consumption [99,100]. Highly palatable, energy-dense, low-cost, ultra-processed foods, snacks, and beverages are commonplace within the
This is evident in the growing number of supermarkets that are replacing open public markets in LMICs [12]. Consumers are attracted to these foods because of their affordability, ease of access, availability, and taste, which are often accompanied by intensive marketing by the food industry sector [103], particularly in poorer environments where alternatives are limited [104]. In most LMICs, food security is a major issue and food preservation using salt is commonplace. In these countries, food production is seasonal but in greater quantities during harvest, after which production dwindles significantly [14, 15]. Ghana, for example, experiences two rainy seasons a year (with the major one in June and the minor in October) and those are the times for crop production in most parts of the country [105]. The major fishing season shares the same timeframe [106,107], thus, the bulk of the country’s food supply is produced in one-half of the year, thereby warranting preservation, one of which is using salt [108] to ensure its availability and maintenance for off-season supply [14,15]. Often, an under-estimated source of dietary salt relates to the contribution from the water supply. Studies on river and underground shallow water salinity are lacking in the face of severe drought in LMICs [109–111]. More challenging is the fact that there are no guidelines for safe salinity levels in drinking water [21]. During the dry season in Bangladesh, it is estimated that up to 5–16 g salt per day may be consumed from river and shallow underground drinking water [47]. There are many places in Africa and Asia where the sources of water are unsafe for human consumption [112–114] and the likelihood for excess salt provided by water bodies remain high as environmental and climatic conditions worsen [115]. This issue has been ignored in recommended global strategies [20] to reduce population-level salt intake. The shift in dietary patterns is also driven by the promotion of Western culture through media outlets, international trade, and other channels related to globalization [74]. Many supermarkets, hotels, restaurants, and fast food outlets in LMICs are multinational establishments that provide the same menu as their partners in higher income countries. These food outlets are a major driving force changing the food environment and dictating food preferences in LMICs [12]. Globalization of food systems in this way, undermines traditional dietary practices and creates an avenue for food and nutrient insecurity. Greater availability and
access to these cheap, imported, energy-dense, nutrient-poor foods have culminated in an increased prevalence of obesity and a myriad of NCDs plaguing many African countries (that are already burdened with infectious diseases) [116]. A challenge is for LMICs to consider agriculture within economic growth and development, to ensure that food insecurity is not exacerbated by increasing urbanization. A deliberative approach should be developed and geared towards the production, availability, accessibility, and consumption of a wide range of traditional staples in the face of rapid development. Countries in South East Asia provide exemplars as they have encouraged and improved the traditional cuisine to meet current developmental changes [117,118]. The United Nations’ Sustainable Development Goals provide a framework against which country progress towards 17 goals will be reported by governments [119]. Partnerships and global solidarity between countries should include commitments by major food companies to limit and standardize acceptable maximum limits of harmful components allowed in imported or branded foods sold across the globe and prevent dramatic differences currently seen in the salt content of similar products and fast food meals across countries. An urgent need to address food systems in LMICS is required in order to stem the pandemic of NCDs, as more than three-quarters of premature NCD deaths occur in these countries [20]. South Africa serves as an example where the government has mandated maximum salt levels permitted across a wide range of processed foods, in an effort to reduce the burden of hypertension [8, 120, 121] and its related morbidities [122]. Though the impact of this legislation is yet to be demonstrated [123], it is seen as a bold step towards saving lives and reducing health care costs [124, 125]. The WHO has emphasized that government policies and programs, collaboration with private sector organizations, and monitoring of population salt intake are key measures to population salt reduction [20]. Understanding salt use behaviors at the population level is required in order to determine best approaches to salt reduction in countries [126]. Many governments have focused on individual consumer behavior change [127], focusing on salt added at the table and during cooking. Though commendable, a multi-faceted approach which targets both discretionary and non-discretionally salt use is encouraged [20]. This review collated the available information on dietary sources of salt in LMICs in an effort to
identify the food sources that contribute to total salt intake. Many LMICs do not have reliable assessments of dietary salt intake nor do they have national targets and timelines towards ensuring a decline in salt consumption. This makes it challenging to assess progress towards achieving the WHO’s voluntary salt reduction target of a relative 30% by 2025 [20]. Advocacy by civil society groups, organizations, institutions, and professional health associations for salt reduction in foods is required to lobby governments whose health agenda does not include changes to the food supply. This approach has been demonstrated by the Australian Division of World Action on Salt and Health, whose efforts have resulted in voluntary salt targets for the food industry [71]. The legislative approach adopted by the South African government [41] may serve as blueprint for LMICs [128]. Limitations to the review relate to the selection criteria being based on the English language only. This may have limited the scope of the search and subsequent data retrieved for consideration. Nonetheless, studies included covered all WHO global regions. Many of the cited papers did not provide information on the actual dietary consumption patterns of the populations residing in the areas from where the food samples were obtained. This means that overall contribution of individual foods to total salt intake could not be determined.

3.5 Conclusions

Processed foods that have a high salt content are becoming common place in the diets of populations in LMICs. Major sources of salt are provided by bread, meat and meat products, salted meat and fish, sauces, spreads, bouillon cubes, pizza, and seafood. Differences exist between WHO regions regarding sources of food products that contribute to total salt intakes. Water sources in drought-affected areas also warrant further attention as sources of Na intake. Besides foods that contain high salt, discretionary salt use is widespread in LMICs.

Supplementary Materials: The following are available online at http://www.mdpi.com/1660-4601/16/12/2082/s1, Table S1: Search strategy, Table S2: Risk of bias assessment, Table S3: Included articles and their regions of origin. Author
3. 6 References


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Chapter 4

Salt use behaviours of Ghanaians and South Africans: A comparative study of knowledge, attitudes and practices

This chapter describes a cross-sectional study of salt use behaviours among Ghanaians and South Africans during WHO-SAGE W2 study. In terms of advocacy and affirmative action for population salt reduction, salt knowledge, attitudes and practices are the targets of public health education. A comparison between the two SSA countries, with SA having implemented a salt reduction legislation, in addition to a massive salt reduction campaign, and Ghana without such, this novel study gives an insight into salt behaviours among these two different environments.

This chapter is the substantive content of the published work:
Abstract

Salt consumption is high in Africa and the continent also shares the greatest burden of hypertension. This study examines salt-related knowledge, attitude and self-reported behaviours (KAB) amongst adults from two African countries—Ghana and South Africa (SA)—which have distributed different public health messages related to salt. KAB was assessed in the multinational longitudinal World Health Organization (WHO) study on global AGEing and adult health (WHO-SAGE) Wave 2 (2014–2015). Respondents were randomly selected across both countries—Ghana (n = 6746; mean age 58y old; SD 17; 41% men; 31% hypertensive) and SA (n = 3776, mean age 54y old; SD 17; 32% men; 45% hypertensive). South Africans were more likely than Ghanaians to add salt to food at the table (OR 4.80, CI 4.071–5.611, p < 0.001) but less likely to add salt to food during cooking (OR 0.16, CI 0.130–0.197, p < 0.001). South Africans were also less likely to take action to control their salt intake (OR 0.436, CI 0.379–0.488, p < 0.001). Considering the various salt reduction initiatives of SA that have been largely absent in Ghana, this study supports additional efforts to raise consumer awareness on discretionary salt use and behaviour change in both countries.

This data was presented at a conference in Accra, Ghana:
4.1 Introduction

The Global Burden of Disease study has demonstrated that diet contributes significantly to risk of non-communicable diseases (NCDs) such as cancer, cardiovascular diseases (CVDs) and diabetes [1]. Dietary risk factors include diets low in fruits, vegetables, whole grains, nuts and seeds, fibre, omega-3 oils, and polyunsaturated fatty acids and diets that are high in Na, red meat, processed meat, sweetened beverages, and trans fats [2,3,4,5,6]. The nutrition transition in many Sub-Saharan countries is resulting in a change in dietary patterns from traditional, plant-based diets to increasing intakes of processed foods that tend to be high in sugar and/or fat, known as energy dense, nutrient poor (EDNP) foods that are generally also high in salt [7]. Excess salt intake has been identified as one of the leading global health risks [8] and population level salt reduction is recognized as a cost-effective means of reducing BP [9,10,11,12] and, in turn, reducing the risk of heart disease and stroke [13,14]. A 30% reduction in population level salt by 2020 is one of the voluntary global health targets identified by the WHO [7].

On a global scale, it has been estimated that 1.7 million lives could be saved annually if salt consumption levels were decreased to recommended levels of less than 5g per day [15]. Across high and low-middle income countries, interventions to reduce population salt intake are considered cost effective (less than $1USD per person per year) [16, 17].

Over 75% of cardiovascular deaths take place in low and middle-income countries [18] with the African region estimated to have around 20 million people with CVD [18]. As such, Africa shares the greatest burden of hypertension with almost half of adults aged 25 and older diagnosed and potentially more adults with undiagnosed, untreated and uncontrolled hypertension [19]. In Ghana, the prevalence of hypertension has continued to rise over the past 40y [20, 21, 22]. South Africa (SA) equally shares a large burden of hypertension [23, 24]. The direct healthcare costs attributable to non-optimal BP in Sub-Saharan Africa (SSA) in 2001 were estimated to be two billion US dollars [25].

Despite the global targets to reduce the burden of NCDs, there are still limited examples of effective strategies to reduce population-level dietary salt consumption globally, especially from African countries [26, 27]. In most African countries, salt is commonly added to food
at the table and during cooking, and is a major ingredient found in commonly used sauces and seasonings [28, 29]. Salted fish and meat are eaten frequently [30] while bread contains levels of salt that are generally higher than in countries in Europe and North America [31, 32]. In SA, other sources of salt include cereals, meat and meat products, milk and dairy products, processed meats, meat pies and margarine. In that country, it is estimated that discretionary salt intake accounted for almost half of the total dietary intake in a sample of black urban dwelling people [33]. This represents a greater contribution as compared to many high-income countries, where 75–85% of dietary salt intake is estimated to come from processed foods [34]. The Ghana Demographic and Health Survey indicated that 84% of women surveyed reported that someone in their household had consumed processed foods containing salt within the past 24 hours, while more than a third had consumed salted dried fish, 21% reported having had canned fish, meat and legumes and 24% reported the use of other processed foods containing salt [35]. The report identified a high use of salty foods in both rural and urban areas. Similarly, the South African Demographic and Health Survey 2003 indicated that more than 30% of survey respondents reported adding salt to food at the table and consuming salty snacks more than twice a week [36].

To reduce discretionary salt consumption in SA, there has been a concentrated focus on consumer education and awareness in recent years [37]. In addition, in June 2016, the SA government implemented mandatory legislation related to maximum levels of salt permitted in a wide range of processed food categories, including breads, meats, cereal products, fat spreads, snack foods and savoury products [38]. These foods have previously been shown to contribute significantly to overall non-discretionary salt intake in the South African population [33]. In contrast, in Ghana, there have been no concerted efforts by government or non-governmental organizations to implement salt reduction strategies. Instead, there has been a focus on the prevention of iodine deficiency through universal salt iodization programmes [39, 40, 41] with the message to consume iodized salt widely disseminated through the mass media [39]. Public health concerns related to the association between increased salt intake and cardiovascular risk in Ghana have received comparatively little attention despite promising proof of concept studies [42]. Iodization
programmes and salt reduction strategies are not mutually exclusive, as has been
demonstrated [43]. However, for both programmes to successfully coexist, different sectors
of government (nutrition and NCDs) need to work together, to effectively monitor the
iodine status of populations as salt content in the food supply decreases.

Given that the population in Ghana has been urged to consume iodized salt [39,40,44]
combined with the generally increased accessibility of EDNP processed foods, it is timely to
investigate knowledge, attitudes and behaviours (KAB) related to salt use in Ghana and to
compare these against SA, an African country in which salt reduction has been strongly
emphasized. Ghana and SA share similar socio-demographic characteristics, as well as a
high hypertension burden. The findings will be important—particularly for low and
middle-income countries—for informing approaches to reducing the health risks through a
better understanding of salt intake behaviours.

4.2. Methods

The study methodology has been comprehensively described in Chapter two. Specific to
this chapter, WHO-SAGE Ghana/SA W2 dataset was utilized. A total of 10,522 adults were
recruited: n = 6746 in Ghana and n = 3776 in SA. In selecting the sample, all WHO-
SAGE W1 households were included for WHO-SAGE W2 data collection [45]. Field teams used an 11-
month period (September 2014 to June 2015) and a 5-month period (August to December
2015) to complete data collection in Ghana and SA, respectively.

4.2.1 Study Measures

The main outcome of this analysis relates to reported salt KAB captured using a five-item
questionnaire adapted from the WHO/PAHO protocol [46]. KAB is the usual term for such
research and has been widely used in the context of salt behaviours [47, 48, 49, 50]. The
congruence between attitudes and perceptions has been explored [50], but for the purposes
of comparison with other studies we prefer to retain the terminology of “attitudes”. Age,
sex, residential location (urban/rural), education, marital status, employment status, alcohol
intake, smoking status, blood pressure (BP) and salt behaviour variables were recorded, as
shown in Table 4.1. Approval for the study and informed consent statements from participants have been described in Chapter 2.
Table 4. 1 Sociodemographic characteristics and selected health characteristics of the study samples in Ghana and South Africa, Study on Global Ageing and Adult Health (SAGE) Wave 2.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Age Categories — Countries Combined</th>
<th>Ghana n = 4753</th>
<th>South Africa n = 3392</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>18–49 years old (n = 2279)</td>
<td>50+ years old (n = 5860)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age in years, median (IQR)</td>
<td></td>
<td>n = 4743</td>
<td>n = 3396</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>50 plus years, n (%)</td>
<td></td>
<td>58 (19.0)</td>
<td>54 (24.0)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3569 (75.2)</td>
<td>2919 (67.5)</td>
<td></td>
</tr>
<tr>
<td>Sex male, n (%)</td>
<td>n = 2277</td>
<td>n = 5857</td>
<td>1954 (41.1)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td></td>
<td>871 (38.3)</td>
<td>2171 (37.0)</td>
<td>1094 (32.3)</td>
<td></td>
</tr>
<tr>
<td>Residence urban, n (%)</td>
<td>n = 2110</td>
<td>n = 5560</td>
<td>1970 (41.6)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td></td>
<td>1176 (55.7)</td>
<td>2918 (52.5)</td>
<td>2124 (72.8)</td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td>1970 (41.6)</td>
<td>2124 (72.8)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Ever attended school, n (%)</td>
<td>n = 2108</td>
<td>n = 5546</td>
<td>2918 (52.5)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td></td>
<td>1839 (87.2)</td>
<td>3327 (60.0)</td>
<td>2124 (72.8)</td>
<td></td>
</tr>
<tr>
<td>Educational level high school or above, n (%)</td>
<td>n = 2099</td>
<td>n = 5493</td>
<td>2764 (58.4)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td></td>
<td>1164 (55.5)</td>
<td>1646 (30)</td>
<td>678 (14.4)</td>
<td></td>
</tr>
<tr>
<td>Employment status: currently working, n (%)</td>
<td>n = 1473</td>
<td>n = 4832</td>
<td>4537 (69.8)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td></td>
<td>1124 (76.3)</td>
<td>2611 (54.0)</td>
<td>566 (32.0)</td>
<td></td>
</tr>
<tr>
<td>Characteristics</td>
<td>Age Categories — Countries Combined</td>
<td>Ghana</td>
<td>South Africa</td>
<td></td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
<td>-------------</td>
<td>----------------------------------</td>
<td>----</td>
</tr>
<tr>
<td></td>
<td>18–49 years old (n = 2279) vs 50+ years old (n = 5860)</td>
<td>p Value</td>
<td>n = 4753</td>
<td>n = 3392</td>
</tr>
<tr>
<td>Marital status: married/cohabiting, n (%)</td>
<td>n = 937</td>
<td>&lt;0.01</td>
<td>2692 (56.8)</td>
<td>915 (31.3)</td>
</tr>
<tr>
<td></td>
<td>231 (24.7)</td>
<td></td>
<td>2912 (57.2)</td>
<td>2313 (39.0)</td>
</tr>
<tr>
<td></td>
<td>684 (34.5)</td>
<td></td>
<td>1553 (33.7)</td>
<td>1347 (39.6)</td>
</tr>
<tr>
<td>Waist to height ratio &lt;0.5, n (%)</td>
<td>n = 1853</td>
<td>&lt;0.01</td>
<td>4347</td>
<td>2313</td>
</tr>
<tr>
<td></td>
<td>693 (37.4)</td>
<td></td>
<td>1553 (33.7)</td>
<td>509 (22.0)</td>
</tr>
<tr>
<td></td>
<td>4807</td>
<td></td>
<td>1369 (28.5)</td>
<td>509 (22.0)</td>
</tr>
<tr>
<td></td>
<td>1369 (28.5)</td>
<td></td>
<td>1553 (33.7)</td>
<td>509 (22.0)</td>
</tr>
<tr>
<td>Body Mass Index (BMI), median (IQR)</td>
<td>n = 1904</td>
<td>&lt;0.01</td>
<td>4456</td>
<td>2331</td>
</tr>
<tr>
<td></td>
<td>25 (7.7)</td>
<td></td>
<td>22.9 (6.2)</td>
<td>28.6 (9.9)</td>
</tr>
<tr>
<td></td>
<td>2483</td>
<td></td>
<td>22.9 (6.2)</td>
<td>28.6 (9.9)</td>
</tr>
<tr>
<td></td>
<td>22.4 (8.4)</td>
<td></td>
<td>22.9 (6.2)</td>
<td>28.6 (9.9)</td>
</tr>
<tr>
<td>Alcohol intake</td>
<td>n = 1597</td>
<td>0.87</td>
<td>1168</td>
<td>2054</td>
</tr>
<tr>
<td>Never n (%)</td>
<td>397 (24.0)</td>
<td></td>
<td>786 (67.5)</td>
<td>1639 (80.0)</td>
</tr>
<tr>
<td></td>
<td>400 (24.6)</td>
<td></td>
<td>786 (67.5)</td>
<td>1639 (80.0)</td>
</tr>
<tr>
<td>Recently yes, n (%)</td>
<td>n = 515</td>
<td>0.41</td>
<td>1379</td>
<td>515</td>
</tr>
<tr>
<td></td>
<td>351 (68.2)</td>
<td></td>
<td>916 (66.4)</td>
<td>347 (67.4)</td>
</tr>
<tr>
<td></td>
<td>912 (66.1)</td>
<td></td>
<td>916 (66.4)</td>
<td>347 (67.4)</td>
</tr>
<tr>
<td>Frequent, n (%)</td>
<td>n = 508</td>
<td>&lt;0.01</td>
<td>1369</td>
<td>510</td>
</tr>
<tr>
<td></td>
<td>203 (40.0)</td>
<td></td>
<td>635 (46.4)</td>
<td>163 (32.0)</td>
</tr>
<tr>
<td></td>
<td>595 (43.4)</td>
<td></td>
<td>635 (46.4)</td>
<td>163 (32.0)</td>
</tr>
<tr>
<td>Smoking status, current use of tobacco, n (%)</td>
<td>n = 1616</td>
<td>&lt;0.01</td>
<td>1340</td>
<td>2160</td>
</tr>
<tr>
<td></td>
<td>137 (8.5)</td>
<td></td>
<td>208 (15.5)</td>
<td>403 (18.7)</td>
</tr>
<tr>
<td></td>
<td>474 (25.2)</td>
<td></td>
<td>208 (15.5)</td>
<td>403 (18.7)</td>
</tr>
<tr>
<td>Systolic blood pressure mm Hg, median (IQR)</td>
<td>n = 2030</td>
<td>&lt;0.01</td>
<td>4674</td>
<td>2726</td>
</tr>
<tr>
<td></td>
<td>119 (20.0)</td>
<td></td>
<td>124.67 (28.0)</td>
<td>130.7 (26.0)</td>
</tr>
<tr>
<td></td>
<td>131 (28.0)</td>
<td></td>
<td>124.67 (28.0)</td>
<td>130.7 (26.0)</td>
</tr>
<tr>
<td>Characteristics</td>
<td>Age Categories — Countries Combined</td>
<td>18–49 years old (n = 2279)</td>
<td>50+ years old (n = 5860)</td>
<td>p Value</td>
</tr>
<tr>
<td>-------------------------</td>
<td>-----------------------------------</td>
<td>---------------------------</td>
<td>--------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>Diastolic blood pressure mm Hg, median (IQR)</td>
<td>n = 2030</td>
<td>n = 5370</td>
<td>&lt;0.01</td>
<td>n = 4674</td>
</tr>
<tr>
<td></td>
<td>75.7 (15.0)</td>
<td>79.3 (17.0)</td>
<td></td>
<td>77 (16.0)</td>
</tr>
<tr>
<td>Hypertensive, n (%)</td>
<td>n = 2079</td>
<td>n = 5455</td>
<td>&lt;0.01</td>
<td>n = 4675</td>
</tr>
<tr>
<td></td>
<td>401 (19.3)</td>
<td>2320 (42.5)</td>
<td></td>
<td>1444 (30.9)</td>
</tr>
</tbody>
</table>

Data recorded as median (inter quartile range) and frequencies (%). Smokers identified by self-report. Frequent alcohol use defined as the consumption of one or more alcoholic drinks a day/week. Hypertensive categorized as BP ≥ 140/90 mm Hg or previous diagnosis. Continuous variables were compared using the Independent Samples Mann Whitney U test; categorical variables were compared using the Chi-Square test.
4.2.2 Statistical Analysis

All data were collated and analysed using IBM SPSS Statistics for Windows, Version 20.0. (IBM Corp., Armonk, NY, USA). The normality of the data was checked by visual inspection and the Kolmogorov-Smirnov test. Descriptive statistics of frequencies, percentages and median (IQR) were used to describe respondents’ characteristics and responses to survey items. Country differences were evaluated using Chi-square and Independent Samples Mann Whitney U tests. The significance level was set at $p < 0.05$. Logistic regression was applied to compare the probability of various salt behaviours between Ghana and SA and odds ratios and 95% confidence intervals (95% CI) were computed. The model was adjusted for potential confounders which included age, sex, residential location, educational level and hypertension prevalence as demonstrated in other studies [51-53]. BMI was not included in the final regression model as it was not statistically significant.

4.3 Results

Approximately 30% of the recruited samples in both countries had data that could not be retrieved due to technical and data management issues during data collection and retrieval using the CAPI system. This loss of data was non-systematic and the sample size on which the current analysis is based is on a total samples size of $n = 8145$ (by sex). As such, in the sample for Ghana (41.1% ($n = 1954$) were male and 58.9% ($n = 2799$) were female, 75.2% ($n = 3569$) aged 50+y old and 24.8% ($n = 1174$) aged 18–49 years old) and for SA (32.2% ($n = 1094$) were male and 67.8% ($n = 2298$) were female, 67.5% ($n = 2291$) aged 50+y old and 32.5% ($n = 1105$) aged 18–49y old). The characteristics of the population are presented in Table 4.1. Due to non-responses for some questionnaire items, the number of responses ($n$) for each variable is included in the tables. Significant differences were recorded between the two countries, with more older people (Ghana 75.2%; SA 67.5%; $p < 0.01$) and more men (Ghana 41.1%; SA 32.3%; $p < 0.01$) in Ghana than in SA, whereas SA had more urban residents (Ghana 41.6%; SA 72.8%), and more participants from SA had a higher educational status (Ghana 14.4%; SA 42.1%) and a higher level of hypertension prevalence (SA 44.7%; Ghana 30.9%; $p < 0.01$)
4.3.1 Knowledge
Approximately one-third (31.3%; n = 2190) of all respondents were not aware that a high salt diet could cause a serious health problem. This was consistently observed among older and younger adults, men and women and across both countries (Table 5.2). Significant associations were recorded between respondents’ knowledge and their ethnicity within the South African cohort. Those with a “coloured” ethnic background recorded the highest knowledge (84%, p < 0.01).
Table 4. 2 Association between salt knowledge, attitudes and behaviours (KAB) and demographic characteristics of Ghanaians (n = 6746) and South Africans (n = 3776); younger (n = 2279) and older (n = 5860); men (n = 3048) and women (n = 5860), SAGE Wave 2.

<table>
<thead>
<tr>
<th>Age Category — Countries Combined</th>
<th>Sex — Countries Combined</th>
<th>Ghana</th>
<th>SA</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>18–49 years old</td>
<td>50+ years old</td>
<td>p Value</td>
<td>Men</td>
<td>Women</td>
</tr>
<tr>
<td>n = 2279</td>
<td>n = 5860</td>
<td></td>
<td>n = 3048</td>
<td>n = 5097</td>
</tr>
<tr>
<td>Do you think that a high salt diet could cause a serious health problem?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes n (%)</td>
<td>1940 (67.5)</td>
<td>5061 (69.2)</td>
<td>0.16</td>
<td>n = 2602</td>
</tr>
<tr>
<td>How much salt do you think you consume?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Just the right amount, n (%)</td>
<td>2047 (78.8)</td>
<td>5392 (73.4)</td>
<td>&lt;0.01</td>
<td>n = 2804</td>
</tr>
<tr>
<td>Do you add salt to food at the table?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>“Always” and “Often” n (%)</td>
<td>1453 (21.4)</td>
<td>4026 (16.7)</td>
<td>&lt;0.01</td>
<td>n = 2024</td>
</tr>
<tr>
<td>Age Category—Countries Combined</td>
<td>Sex—Countries Combined</td>
<td>Ghana</td>
<td>SA</td>
<td>p Value</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-----------------------</td>
<td>-------</td>
<td>----</td>
<td>---------</td>
</tr>
<tr>
<td>18–49 years old n = 2279</td>
<td>50+ years old n = 5860</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p</td>
<td>p</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men n = 3048</td>
<td>Women n = 5097</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value</td>
<td>Value</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n = 1822</td>
<td>n = 4771</td>
<td>0.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1689 (92.7)</td>
<td>4310 (90.3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>“Always” and “Often” n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n = 2552</td>
<td>n = 4041</td>
<td>&lt;0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2374 (93)</td>
<td>3625 (89.7)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do you do anything on a regular basis to control your salt or sodium intake? Yes n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n = 1990</td>
<td>n = 5249</td>
<td>0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>688 (34.6)</td>
<td>2034 (38.8)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Note: “All” represents respondents from both countries. Data was recorded in frequencies. Chi square tests were conducted.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.3.2 Attitudes
Three quarters (74.9%; n = 5570) of all respondents perceived that they consumed just the right amount of salt. The perception of consuming “just the right amount of salt” was more frequently observed in younger adults, men, and in Ghanaians compared to South Africans.

4.3.3 Salt intake behaviours
Among all respondents, 18% (n = 984) reported that they “always” and “often” (frequently) added salt to food at the table and the majority (n = 5999, 91%) reported that they frequently added salt to food at home during cooking. Almost two-thirds (62.4%) reported that they did not take any action to control their salt intake. The response to “taking actions to control salt intake on a regular basis” significantly differed according to knowledge about salt (knowledge and health, p < 0.001). For the two countries, fifty-two percent of respondents who did not think high salt could cause health problems reported that they never took actions on regular basis to reduce salt intake. Reported frequent alcohol intake was found to relate to less desirable salt intake behaviours. While 96.7% of respondents reporting frequent alcohol intake (n = 1971) also reported always or often adding salt to food while cooking, this behaviour was significantly lower (86.1%) in teetotallers (n = 756; p < 0.01). Additionally, significantly more teetotallers (51.0%) reported regularly attempting to control their salt intake when compared with frequent drinkers (33.7%; p < 0.01). Significant associations were recorded between respondents who frequently added salt to food at the table and their ethnicity within the South African cohort. Those with African/black ethnic background reported adding more salt to food at the table than any other group (36.5%, p < 0.01).

Younger adults more frequently added salt to food at the table, added salt to food eaten at home during cooking and did less on a regular basis to control their salt intake than did older adults (Table 4.2). More South Africans than Ghanaians reported that they frequently added salt at the table (SA 32.9%; Ghana 9.9%; p < 0.001) and did not take actions to control their salt intake (SA 28.8%; Ghana 42.9%). Significantly more Ghanaians than South Africans reported frequently adding salt to food during cooking (SA 79.9%; Ghana 96.3%; p < 0.01).
Multivariate analysis adjusted for sex, age, residence, educational level and hypertension prevalence showed that South Africans were more likely than Ghanaians to add salt to food at the table (OR 4.80, CI 4.071–5.611, p < 0.001) but less likely to add salt to food at home during cooking (OR 0.16, CI 0.130–0.197, p < 0.001) or to take action to control their salt intake regularly (OR 0.44, CI 0.379–0.488, p < 0.01); (Table 4.3). Men and younger adults were also significantly more likely to add salt to food and less likely to control salt intake. Those living in urban areas, educated to high school level or above, or those with hypertension were significantly more likely to regularly control their salt intake.
Table 4. Associations between sociodemographic variables and salt behaviours of adults in Ghana (n = 6746) and South Africa (n = 3776) - comparing the odds ratio for sub-optimal salt behaviours, SAGE Wave 2.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Salt Frequently Added to Food at the Table</th>
<th>Salt Frequently Added to Food during Cooking</th>
<th>Takes Regular Action to Control of Salt Intake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ghana South (SA)</td>
<td>Referent</td>
<td>Ref</td>
<td>Ref</td>
</tr>
<tr>
<td></td>
<td>4.80 (4.071–5.611) *</td>
<td>0.16 (0.130–0.197) *</td>
<td>0.436 (0.379–0.488) *</td>
</tr>
<tr>
<td>Female</td>
<td>Referent</td>
<td>Ref</td>
<td>Ref</td>
</tr>
<tr>
<td>Male</td>
<td>1.40 (1.182–1.605) *</td>
<td>1.36 (1.118–1.654) *</td>
<td>0.78 (0.718–0.884) *</td>
</tr>
<tr>
<td>18–49y old</td>
<td>Referent</td>
<td>Ref</td>
<td>Ref</td>
</tr>
<tr>
<td>50+y old</td>
<td>0.78 (0.655–0.920)</td>
<td>0.56 (0.450–0.711) *</td>
<td>1.23 (1.096–1.384) *</td>
</tr>
<tr>
<td>Rural</td>
<td>Referent</td>
<td>Ref</td>
<td>Ref</td>
</tr>
<tr>
<td>Urban</td>
<td>0.89 (0.762–1.041)</td>
<td>0.90 (0.744–1.099)</td>
<td>1.41 (1.271–1.565) *</td>
</tr>
<tr>
<td>Primary school and below</td>
<td>Referent</td>
<td>Ref</td>
<td>Ref</td>
</tr>
<tr>
<td>High school and above</td>
<td>0.87 (0.741–1.020)</td>
<td>0.86 (0.710–1.048)</td>
<td>1.12 (1.004–1.240) *</td>
</tr>
<tr>
<td>Normotensive</td>
<td>Referent</td>
<td>Ref</td>
<td>Ref</td>
</tr>
<tr>
<td>Hypertensives</td>
<td>1.11 (0.952–1.299)</td>
<td>0.88 (0.734–1.067)</td>
<td>1.48 (1.328–1.649) *</td>
</tr>
</tbody>
</table>

Note: Referent indicates reference category used for the comparison. Hypertension was categorized as BP ≥ 140/90 mm Hg or previous diagnosis, logistic regression was adjusted for sex, age category, residence, educational level and hypertension prevalence, * p < 0.05.
4.4 Discussion

The finding that 80% or more of adults in Ghana and SA frequently add salt to their food during cooking indicates that discretionary salt use remains high in both countries. Significant differences were observed between the two countries for various behaviours, such as a third of South Africans reported adding salt to food at the table as compared to only a tenth of Ghanaians. Significant differences were also observed between younger and older adults and between the genders. The most potentially detrimental behaviours were identified in men and younger adults. The contribution of discretionary salt intake to total salt intake cannot be under-emphasized even in societies where most salt comes from processed foods. Health promotion activities are needed to decrease individual level salt intake [7] in order to decrease salt preferences over time and thus decrease discretionary salt use [7,36,54].

Knowledge related to the adverse effects of salt on health was poor. Almost one third (n = 2190) of both Ghanaians and South Africans were not aware of the relationship between high salt intake and the possibility of a serious health problem. This could potentially explain practices of high discretionary salt use [51, 55, 56]. Conversely, individuals who know about the health effects of excess salt in the diet have been shown to be more likely to reduce their salt intake [47]. Knowledge of hypertension may influence both salt and self-care behaviours [57]. Our results show that responses to salt knowledge, attitudes and behaviours are significantly related as shown by other authors [52].

Our data indicates participants’ high confidence in their perceived intake of the recommended levels of salt, since three-quarters of respondents reported that they consumed “just the right amount of salt.” A limitation of this study relates to potential under-reporting of salt use, as shown in other studies [47, 50, 58, 59] and responses to salt questions may not reflect actual intakes. Studies that measured 24 h urinary Na excretion in addition to self-reported discretionary salt use in the same respondents revealed an underestimation in reported salt intake [33, 60]. Hypertension levels were high in both
samples, but we did not investigate whether hypertensive individuals that were receiving treatment to control their BP had also received advice on salt intake. There is a possibility of misreporting, as those who have received information on salt use may feel that they consume the recommended amount. Furthermore, there might be some lack of knowledge relative to the amount of salt recommended for daily consumption, as was the case in other studies [52]. This discrepancy between perceived and actual salt consumption has the potential to result in higher than anticipated salt intakes [61].

Our data indicates a need to intensify consumer education on salt intake awareness in both countries, including discretionary salt use. Previous research contributing to South African policy change [33] suggests that further investigation into particular food items that contribute high amounts of salt to the diet is needed in Ghana. Consistent with other studies [52], more attention should be directed towards the younger population (18–49y old) and to men, who reported worse discretionary salt knowledge, attitudes and behaviours. Dietary salt education and awareness should also be integrated into school curricular and youth programmes, particularly as hypertension and associated morbidity and mortality typically occur at younger ages in Sub Saharan Africa (SSA) [62, 63].

Our finding that Ghanaians add more salt to food at home during cooking compared with their South African counterparts may not be surprising given investment in campaigns to increase consumption of iodized salt [64-66]. Within Ghana, any action related to salt reduction for addressing NCDs appears to have been overshadowed by the strong focus on the prevention of iodine deficiencies [39,40,41,66]. This situation appears in contrast to WHO guidelines [14], which suggest compatibility of polices on salt reduction and salt iodisation. The guidelines advise that regular monitoring of salt intake and iodine intake at country level is needed to adjust salt iodisation over time to ensure that individuals consume sufficient iodine while reducing overall intake of salt. If salt is sufficiently iodised, a reduction of salt intake to the recommended level of 5 g per day should still provide an adequate amount of iodine [43]. Ghana’s strong emphasis on the reduction of iodine deficiencies provides a unique and untapped opportunity for addressing discretionary salt use and behaviour change. Salt used in food processing is not included in the mandatory
Universal Salt Iodisation policies in either Ghana or SA, although there is some evidence from SA that indicates up to a third of margarines, bread, and savoury snack seasonings contain iodised salt [67].

We found that South Africans were almost 5 times more likely than Ghanaians to add salt to food at the table (controlling for sex, age, location, education level and hypertension prevalence). This finding was expected, as a greater proportion of the cohort in SA lived in urban areas compared with Ghana. Urbanization is one of the key drivers for excess salt consumption [15]. Further investigation regarding the effect of acculturation on addition of salt to food is of interest. The survey was conducted prior to salt legislation being introduced in SA, therefore it will be of importance to determine how the lowering of salt in processed foods impacts on both discretionary salt behaviours and actual salt intake levels in SA in the next wave of SAGE in 2017–2018.

The present study shows that almost two-thirds of the population were not taking any action to control their salt intake, and this may be explained by the finding that a third of respondents did not have any knowledge regarding the links between high salt intake and health problems. Among the key broad strategies for salt reduction is individual responsibility and action [7], for example, limiting the consumption of salty snacks and reducing the amount of salt used in cooking. The Health Belief Model explains that perceived seriousness, perceived susceptibility, perceived benefits and perceived barriers are critical evaluations an individual undertakes prior to engaging in a health behaviour [68]. Our data suggests that strategies are required to firstly increase awareness within the Health Belief Model of health promotion as a means of supporting behaviour change. The other broad strategy is at a systemic level—including measures like those adopted in SA to work with food manufacturers to lower salt levels in processed foods.

The findings of the present study were somewhat surprising because, despite the extensive public awareness campaign in SA to address population salt intake levels and influence salt related behaviour (Salt Watch) [37,69] and despite that population reporting greater salt knowledge, it was the Ghanaians who appeared to be more actively controlling their salt intake (Table 2). This highlights the point that knowledge alone is not sufficient to cause a
change in behaviour. Consistent with the present study, research from Newson et al. (2013) [58] showed that almost half of survey respondents were not interested in reducing their salt intake and had no intention of making any changes to their salt consumption in the immediate future. With a large hypertension burden [24], it is likely that some South Africans may not feel empowered to make dietary changes. Additionally, cultural beliefs and practices that encourage salt consumption are also of concern. Salt use for spiritual and religious purposes is commonplace in SA [37] and this would need to be considered in health messages.

The finding that frequent alcohol intake was associated with less desirable salt intake behaviours has been reported by others [70]. Differences in reported alcohol intake between Ghanaian and South African study participants are similar to previous analyses of alcohol consumption from Wave 1 of SAGE which indicated that there were fewer “never” drinkers (lifetime abstainers) in Ghana than in SA, while the South African cohort had more “at risk” drinkers [71].

It is well established that reducing dietary salt to 3 g/day leads to a reduction in BP in both hypertensives and normotensives [72]. Given the current estimated prevalence of hypertension in the African region, it is imperative that salt reduction messages are included in public health campaigns alongside various strategies to support behaviour change while also modifying salt levels in commonly consumed foods. Provision of practical skills and strategies to encourage change in salt intake behaviours is key in this regard.

The present study had several strengths which included the use of large, nationally representative sample sizes in both SA and Ghana. A potential limitation relates to the use of questionnaire, which might be subject to recall bias and may lead to over reporting or under reporting. Additionally, oversampling of older people in keeping with the purpose of the SAGE may limit generalizability of the findings to the population younger than 50 in both countries. Regardless, these are relatively large representations of the 50+ population, with younger comparison groups in both countries.
4.5 Conclusions

This study provided important insights into salt knowledge, attitudes and behaviours (KAB) in SSA. High discretionary salt use remains common practice in the region and needs urgent attention in the face of high and rising hypertension levels. Significant differences in salt KAB were evident between the two countries which suggests the use of different strategies and approaches for combatting high discretionary salt intake may be appropriate, although strategies particularly targeting men and younger adults may be beneficial for both countries. The findings suggest that SA requires investment into public health campaigns to address the practice of adding salt to foods at the table, while in Ghana a focus on changing behaviours related to the use of salt in cooking is required. Campaigns and consumer education strategies—based on the Health Belief Model—may be useful to raise awareness for salt reduction in SSA.

4.6 References


Chapter 5

High salt and low potassium intake among adult Ghanaians: WHO-SAGE Ghana Wave 3

This chapter highlights salt and K intake and their association with BP. The chapter also draws a relationship between salt intake and salt behaviours.

This chapter is the substantive content of the published work:

Abstract

Though Ghana has high hypertension prevalence, the country lacks current national salt consumption data required to build and enhance advocacy for salt reduction. We compared the characteristics of a nationally representative sample of the World Health Organization’s Study on global AGEing and adult health (WHO-SAGE), Ghana (n = 3053) and a randomly selected sub sample (n = 839). We also investigated the relationship between salt intake and BP among adult Ghanaians in the sub sample (median age = 60, cohort formed 27.5% of the WHO-SAGE Wave 3 Ghana study). BP was measured in triplicate and 24hr urine was collected for the determination of urinary Na, K, creatinine (Cr) and iodine levels. Hypertension prevalence was 44.3%. Median salt intake was 8.3g/day, higher in women compared to men (median 8.6, interquartile range (IQR) 7.5g/day vs 7.5, IQR 7.4g/day, p < 0.01), younger participants (18-49 yrs) compared to older ones (50+ yrs) (median 9.7, IQR 7.9g/day vs 8.1, IQR 7.1g/day, p < 0.01) and those with higher Body Mass Index (BMI) > 30 compared to a healthy BMI (18.5-24.9) (median 10.04, IQR 5.1g/day vs 6.2, IQR 5.6 g/day, p < 0.01). More than three quarters (77%, n = 647) of participants had salt intakes above the WHO maximum recommendation of 5g/d, and nearly two thirds (65%, n = 548) had daily K intakes below the recommended level of 90mmol. Dietary Na: K ratios above 2mmol/mmol were positively associated with increasing BP with age. Population-based interventions to reduce salt intake and increase K consumption are needed.

Key words: hypertension, salt intake, potassium, 24hr urine, Ghana
5.1 Introduction

Cardiovascular diseases (CVDs) remain a major contributory factor for mortality and morbidity worldwide, accounting for 17.9 million deaths in 2016, and representing a third of all deaths globally [1]. While LMICs already share the greatest impact of CVD-related deaths, with rates of 300–600 deaths per 100,000 population, these are predicted to increase, causing premature, avoidable loss of lives [2]. Hypertension is a major risk factor for CVD and accounted for more than 50% of CVD-specific deaths in 2012 [3]. It has been estimated that the burden of hypertension will increase to approximately 1.56 billion people globally by 2025, with larger populations of hypertensives living in LMICs [3-5].

Hypertension is a common condition in Ghana, where its prevalence has increased more than two-fold over just two decades (1988-2007) [6]. A recent nationally representative study among participants largely 50y and older, in Ghana, reported the prevalence of hypertension to be 58.9% in adults with about one-fifth of those with hypertension being aware of having the condition [7]. Reducing population-level prevalence of hypertension by 30% by the year 2030 is identified by WHO as one of the nine voluntary global targets to reduce non communicable diseases (NCDs) [8]. Salt reduction has been identified by the WHO as one ‘best buys’ approach to reduce overall CVD risk through lowering of (BP) [9]. Increased consumption of salt (>2 grams Na/day, equivalent to 5 g salt/day) together with insufficient K intake (< 3.5 grams/day) are strongly associated with a number of NCDs including hypertension [10-14]. Several systematic literature reviews, meta-analyses and randomized-controlled trials have shown that reduced Na consumption results in a decline in BP in both hypertensives and normotensive adults [13-17], which saves lives [18]. In view of this, ‘WHO’s SHAKE the Salt Habit’ resource has emphasized the importance of measuring and monitoring population salt consumption patterns in order to inform stakeholders about strategies to reduce salt intake and evaluate the effect of any implemented salt reduction programmes [19]. Though Ghana is committed to the World Health Assembly’s target of 30% relative reduction in the population salt intake by 2025
[10], the country has made slow progress towards achieving the target due to other competing public health priorities and limited resources [20]. Few studies have been conducted to assess salt intake in the Ghanaian population [21]. A lack of recent, nationally representative data on population salt consumption among adults has further been a disincentive for advocacy around salt reduction efforts [22]. The current study was undertaken to obtain a reliable estimate of population salt intake and salt use behaviour, and to assess the relationship between salt and K intake with BP in Ghanaian adults.

5.2 Methods

The study methodology has been described in Chapter two. Specific to this chapter, WHO-SAGE Ghana W3 dataset was used. Data collection was completed over a period of one year (July 2018 - June 2019) with n = 1100 24hr urine samples collected nationwide. Out of 3053 participants recruited for WHO - SAGE Ghana Wave 3, 102 (36.1%) were randomly selected to provide urine samples (nested sub study). Of these, 76.7% (n = 844) had successful (BP) data and 88.6% (n = 976) had complete urine samples. However, fewer participants (n = 839) had a complete urine collection, accompanied with survey, anthropometric and valid BP data (Figure 5.1).
Figure 5.1 Study flow chart.
The 24hr urine was collected, thoroughly mixed, volumes recorded, 3 aliquots of 5ml were generated, and samples kept in cold boxes and transported to NMIMR-UG for Na, K and Cr analyses. Additionally, iodine was assessed for analysis because Ghana had a universal iodine programme in place.

Creatinine excretion in this population was much lower than that reported for many other populations, from which Cr cut-off values have been determined to indicate completeness of 24hr urine collection [23]. Because of this, only urine volume was used to indicate whether urine samples were considered to represent completeness. This approach has been used in other multi-country studies including the International Population Study on Macronutrients and Blood Pressure [INTERMAP] and the International Study of Sodium, Potassium, and Blood Pressure [INTERSALT] [24]. In the first enumerator areas (EAs) sampled within the Accra region, some calculated salt values were unfeasibly high (> 40g/d, n = 40,) due to unacceptable storage conditions [25]. A follow-up validation study conducted in n = 67 participants included the collection of repeated 24hr urine samples from the same participants in one EA (Alajo; n = 19), while an additional two non-urine EAs from the larger survey sample were visited as a comparator (Mataheko; n = 24 and Nima; n = 24). A second laboratory (Liberty Medical Laboratory, Accra) also performed duplicate analyses in the validation study. Values for Dosise EA (n = 23) were excluded after the validation study because they were confirmed as being unfeasible, and the validation study values replaced original measures for the case of Alajo (n = 16; 3 barcodes of urine samples in validation study were excluded because they could not be matched with those of the original study) (Supplementary Table 5.1).

The ratio Na (mmol/L) to K (mmol/L) was created (Na:K) and categorised as low (<2), medium (2-5) or high (>5). Mean Arterial Pressure (MAP) is the average arterial pressure throughout one cardiac cycle, systole, and diastole. MAP was calculated using the formulae: MAP = SBP + 2 (DBP)/3 [26]. Hypertension status was measured as self-reported treatment or having a measured BP ≥ 140/90mm Hg. Hypertension prevalence, awareness, treatment
and control were measured. Individuals with no current medication use and a measured BP <140/90 mm Hg were categorized as non-hypertensive.

5.2.2 Statistical Analysis

Data were analysed using Stata Statistical Software: Release 15 (Stata Corp LLC, 2017; College Station, USA). Data distribution was checked visually and with the Shapiro Wilks test for normality. Descriptive statistics of frequencies, percentages and median (interquartile range, IQR) were used to describe participants’ characteristics. Categorical variables were evaluated using frequencies, Pearson’s Chi-Square and Fisher’s Exact tests. Comparison between groups for non-parametric data was examined using Mann-Whitney U and Kruskal-Wallis tests and Spearman’s Rho was used to test for correlations. Linear regressions were used to evaluate the associations between variables. To test regression slopes for equality between the three salt level groups and between the three Na:K ratio groups, the interaction terms of groups with age was added into the models. To test if a difference in the group’s coefficients (i.e. slope) was present, the F test was applied. If significant, post-estimation was pursued to identify which group differed from the others.

5.3 Results

Table 5.1 compares sociodemographic characteristics of the nested sub study sample with those included in the total Wave 3 survey collection.
Table 5.1 Demographic profile of SAGE GHA W3 survey participants and subsample with valid urine data (urine data considered valid if volume ≥ 300ml)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Main SAGE cohort (n=3053)</th>
<th>Salt sub study sample (n=839)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Years</td>
<td>60 (20)</td>
<td>60 (19)</td>
<td>0.3294</td>
</tr>
<tr>
<td>18-49y, n (%)</td>
<td>717 (23.5)</td>
<td>174 (20.7)</td>
<td>0.0100</td>
</tr>
<tr>
<td>50+y, n (%)</td>
<td>2336 (76.5)</td>
<td>665 (79.3)</td>
<td>0.4494</td>
</tr>
<tr>
<td><strong>Sex, n (%)</strong></td>
<td></td>
<td></td>
<td>0.001</td>
</tr>
<tr>
<td>Men</td>
<td>1183 (38.8)</td>
<td>371 (43.2)</td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>1870 (61.2)</td>
<td>568 (56.8)</td>
<td></td>
</tr>
<tr>
<td><strong>Ethnicity, n (%)</strong></td>
<td></td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Akan</td>
<td>1544 (50.6)</td>
<td>497 (59.2)</td>
<td></td>
</tr>
<tr>
<td>Ewe</td>
<td>216 (7.1)</td>
<td>58 (6.9)</td>
<td></td>
</tr>
<tr>
<td>Ga-Adangbe</td>
<td>224 (7.3)</td>
<td>45 (5.4)</td>
<td></td>
</tr>
<tr>
<td>Gruma</td>
<td>30 (1.0)</td>
<td>6 (0.7)</td>
<td></td>
</tr>
<tr>
<td>Grusi</td>
<td>76 (2.5)</td>
<td>12 (1.4)</td>
<td></td>
</tr>
<tr>
<td>Guan</td>
<td>38 (1.2)</td>
<td>16 (1.9)</td>
<td></td>
</tr>
<tr>
<td>Mande-Busanga</td>
<td>63 (2.1)</td>
<td>3 (0.4)</td>
<td></td>
</tr>
<tr>
<td>Mole-Dagbon</td>
<td>174 (5.7)</td>
<td>24 (2.9)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>612 (20.0)</td>
<td>174 (20.7)</td>
<td></td>
</tr>
<tr>
<td><strong>Residence, n (%)</strong></td>
<td></td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Urban</td>
<td>1301 (42.6)</td>
<td>457 (54.5)</td>
<td></td>
</tr>
<tr>
<td>Rural</td>
<td>1752 (57.4)</td>
<td>382 (45.5)</td>
<td></td>
</tr>
<tr>
<td><strong>Marital status, n (%)</strong></td>
<td></td>
<td></td>
<td>0.02</td>
</tr>
<tr>
<td>Never married</td>
<td>208 (6.8)</td>
<td>39 (4.6)</td>
<td></td>
</tr>
<tr>
<td>Married/cohabiting</td>
<td>1760 (57.7)</td>
<td>470 (56.0)</td>
<td></td>
</tr>
<tr>
<td>Separate/divorced</td>
<td>369 (12.1)</td>
<td>87 (10.4)</td>
<td></td>
</tr>
<tr>
<td>Widowed</td>
<td>715 (23.4)</td>
<td>243 (29.0)</td>
<td></td>
</tr>
<tr>
<td>Never been to school, n (%)</td>
<td>1119 (36.7)</td>
<td>240 (28.6)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>Education (Years)</strong></td>
<td>10 (5)</td>
<td>10 (5)</td>
<td>0.0139</td>
</tr>
<tr>
<td><strong>Body Mass Index (BMI, kg/m²)</strong></td>
<td>24.2 (6.8)</td>
<td>25.4 (7.4)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td><strong>Waist to height ratio</strong></td>
<td>0.54 (0.11)</td>
<td>0.56 (0.13)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Never used alcohol, n (%)</td>
<td>1865 (61.3)</td>
<td>483 (57.6)</td>
<td>0.052</td>
</tr>
<tr>
<td>Never used tobacco, n (%)</td>
<td>2739 (90.0)</td>
<td>759 (90.5)</td>
<td>0.68</td>
</tr>
<tr>
<td>Systolic BP (mm Hg)</td>
<td>124 (26.5)</td>
<td>126.5 (29)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Diastolic BP (mm Hg)</td>
<td>76 (17)</td>
<td>76.5 (17)</td>
<td>0.83</td>
</tr>
<tr>
<td>Characteristics</td>
<td>Main SAGE cohort (n=3053)</td>
<td>Salt sub study sample (n=839)</td>
<td>P-value</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>--------------------------</td>
<td>-------------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>Mean Arterial Pressure (Map) mm Hg</td>
<td>92.5 (19.2)</td>
<td>93.2 (20.7)</td>
<td>0.24</td>
</tr>
<tr>
<td>Hypertension, n(%)</td>
<td>1132 (37.6)</td>
<td>370 (44.3)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Diabetes, n(%)</td>
<td>157 (5.2)</td>
<td>67 (8.0)</td>
<td>0.01</td>
</tr>
<tr>
<td>Portions of fruit, n(%)</td>
<td>1591 (57.4)</td>
<td>442 (54.5)</td>
<td>0.14</td>
</tr>
<tr>
<td>Met WHO’s recommendation of at least 5 servings of fruits and vegetables</td>
<td>642 (21.1)</td>
<td>107 (12.7)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Frequently add salt to food at table, n(%)</td>
<td>2527 (83.0)</td>
<td>672 (80.1)</td>
<td>0.05</td>
</tr>
<tr>
<td>Frequently add salt to food during cooking, n(%)</td>
<td>265 (8.8)</td>
<td>92 (11.0)</td>
<td>0.05</td>
</tr>
<tr>
<td>Believe they consume too much salt, n(%)</td>
<td>2247 (75.9)</td>
<td>651 (80.0)</td>
<td>0.02</td>
</tr>
<tr>
<td>Regularly control of salt intake, n(%)</td>
<td>1243 (42.1)</td>
<td>394 (48.5)</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

Nested sub sample: all respondent with CAPI data and valid urine, sex and age recorded. Some variables may contain missing data. Data are presented as median (IRQ) unless otherwise indicated. Hypertensive by measured BP≥140 and/or 90 mm Hg or previous diagnosis (self-reported). Ethnicity, marital status, education, alcohol/tobacco use and diabetes prevalence by self-report. Mann-Whitney Test used to compare medians, Pearson Chi-Square test and Fisher’s Exact Test used to compare proportional data.

Hypertension prevalence in the nested sub study was 44.3% (n = 370) with 41.4% and 46.1% for men and women respectively. Of those with hypertension, 59.7% were aware of their condition (n = 222) of which 69.1% (n = 154) were receiving prescribed antihypertensive medication. Of those being treated for hypertension, 51% (n = 77) had controlled BP (ie BP ≤ 140/90).

Among participants with both urine, survey data and BP data (n = 839), median intake of salt was equivalent to 8.3g/day (IQR 7.5) (mean = 10.2g ± 7.2). Salt intake was higher in: (1) women compared to men; median 8.6 (7.5)g/day vs 7.5 (7.4)g/day, p < 0.01; (2) younger participants (18-49 yrs) compared to older ones (50+ yrs); median 9.7 (7.9)g/day vs 8.1
(7.1)g/day, p < 0.01; and (3) those with higher BMI (30+) compared to a desirable BMI (18.5-24.9); median 10.04 (5.1)g/day vs 6.2 (5.6)g/day, p < 0.01. There was no significant difference in salt consumption between rural and urban dwellers. Overall, 77.7% (n = 647) of participants had salt intakes above the WHO maximum recommendation of 5g/d, with 38.9% consuming more than twice this level (> 10g/d, n = 321) and 16.3% consuming more than three times the recommended level (> 15g/d, n = 137). More men than women (27.1% (n = 73) vs 19.9% (n = 122); p = 0.02) and older participants than younger ones (24.8% (n = 164) vs 12.1% (n = 21); p <0.01) achieved the WHO’ salt recommendation of ≤ 5g salt/day (Supplementary Tables 5.2 and 5.3).

According to groupings by salt intake (low, < 5g/d; medium, 5-9g/d; high, > 9g/d), those with higher salt intakes were significantly younger, had higher BMI, a higher urinary K excretion, a higher urinary Na: K and lower urinary iodine concentrations. However, BP and hypertension status did not differ between the groups (Table 5.2).

Table 5. 2 Nested cohort by salt excretion levels, low, medium and high salt groups, WHO – SAGE Ghana Wave 3 (2019)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Low salt &lt;5g/d (n = 186)</th>
<th>Medium salt 5-9g/d (n = 269)</th>
<th>High salt &gt;9g/d (n = 378)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age yrs</td>
<td>64 (20)</td>
<td>60 (17)</td>
<td>58 (18)</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Sex male n (%)</td>
<td>n = 185</td>
<td>n = 269</td>
<td>n = 378</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>73 (39.5)</td>
<td>90 (33.5)</td>
<td>105 (27.8)</td>
<td></td>
</tr>
<tr>
<td>Ethnicity (%)</td>
<td>n = 184</td>
<td>n = 268</td>
<td>n = 376</td>
<td>0.03</td>
</tr>
<tr>
<td>Akan</td>
<td>122</td>
<td>168 (62.7)</td>
<td>203 (54.0)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(66.3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ga</td>
<td>7 (3.8)</td>
<td>11 (4.1)</td>
<td>27 (7.2)</td>
<td></td>
</tr>
<tr>
<td>Ewe</td>
<td>14 (7.6)</td>
<td>18 (6.7)</td>
<td>24 (6.4)</td>
<td></td>
</tr>
<tr>
<td>Mole-dagbon</td>
<td>5 (2.7)</td>
<td>6 (2.2)</td>
<td>13 (3.5)</td>
<td></td>
</tr>
<tr>
<td>Mole-busanga</td>
<td>1 (0.5)</td>
<td>0 (0.0)</td>
<td>2 (0.5)</td>
<td></td>
</tr>
<tr>
<td>Grusi</td>
<td>3 (1.6)</td>
<td>3 (1.1)</td>
<td>6 (1.6)</td>
<td></td>
</tr>
<tr>
<td>Guan</td>
<td>0 (0.0%)</td>
<td>11 (4.1%)</td>
<td>5 (1.3)</td>
<td></td>
</tr>
<tr>
<td>Gruma</td>
<td>1 (0.5)</td>
<td>3 (1.1)</td>
<td>2 (0.5)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>31 (16.8)</td>
<td>48 (17.9)</td>
<td>94 (25.0)</td>
<td></td>
</tr>
<tr>
<td>Urban (%)</td>
<td>n = 185</td>
<td>n = 269</td>
<td>n = 378</td>
<td>0.79</td>
</tr>
<tr>
<td>Characteristics</td>
<td>Low salt &lt;5g/d (n = 186)</td>
<td>Medium salt 5-9g/d (n = 269)</td>
<td>High salt &gt;9g/d (n = 378)</td>
<td>p value</td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>--------------------------</td>
<td>-----------------------------</td>
<td>---------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>Education (yrs)</td>
<td>102 (55.1)</td>
<td>149 (55.4)</td>
<td>200 (52.9)</td>
<td>0.07</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>23.8 (6.5)a</td>
<td>25.5 (7.8)</td>
<td>26.2 (7.5)a</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Salt intake g/d</td>
<td>3.6 (1.5)ab</td>
<td>6.7 (2.0)ac</td>
<td>13.4 (8.9)bc</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>K intake, mmol/d</td>
<td>32.0 (25.8)ab</td>
<td>54.9 (43.8)ac</td>
<td>112.3 (115.8)ac</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Na: K</td>
<td>1.7 (1.2)ab</td>
<td>2.0 (1.4)ac</td>
<td>2.3 (1.9)ac</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Urinary iodine excretion, mmol/day</td>
<td>166.2 (168.5)b</td>
<td>148.2 (131.4)a</td>
<td>117.6 (132.8)ac</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Systolic BP, mm Hg</td>
<td>129 (31.0)</td>
<td>126 (31.0)</td>
<td>126.5 (29.0)</td>
<td>0.73</td>
</tr>
<tr>
<td>Diastolic BP, mm Hg</td>
<td>76 (18.0)</td>
<td>75.5 (17)</td>
<td>77.5 (117.0)</td>
<td>0.68</td>
</tr>
<tr>
<td>Pulse pressure, mm Hg</td>
<td>50.5 (16.7)</td>
<td>49.5 (17.6)</td>
<td>49.5 (16)</td>
<td>0.20</td>
</tr>
<tr>
<td>Mean Arterial Pressure (MAP), mm Hg</td>
<td>94.2 (21.3)</td>
<td>110 (41.0)</td>
<td>93.5 (19.4)</td>
<td>0.85</td>
</tr>
<tr>
<td>Hypertension Prevalence, n (%)</td>
<td>94 (50.5)</td>
<td>110 (41.0)</td>
<td>166 (44.3)</td>
<td>0.13</td>
</tr>
<tr>
<td>Hypertension awareness, n (%) of hypertension prevalence</td>
<td>51 (54.8)</td>
<td>62 (55.4)</td>
<td>108 (65.1)</td>
<td>0.16</td>
</tr>
<tr>
<td>Hypertension medication,</td>
<td>31 (60.8)</td>
<td>47 (75.8)</td>
<td>74 (68.5)</td>
<td>0.23</td>
</tr>
<tr>
<td>Characteristics</td>
<td>Low salt &lt;5g/d (n = 186)</td>
<td>Medium salt 5-9g/d (n = 269)</td>
<td>High salt &gt;9g/d (n = 378)</td>
<td>p value</td>
</tr>
<tr>
<td>-----------------------------------------------------</td>
<td>----------------------------</td>
<td>-------------------------------</td>
<td>----------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>current use n (% of hypertension awareness)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertension control, n (% of Hypertension medication)</td>
<td>n = 31 16 (51.6)</td>
<td>n = 47 22 (46.8)</td>
<td>n = 74 39 (52.7)</td>
<td>0.82</td>
</tr>
<tr>
<td>Stroke, n (%)</td>
<td>n = 185 6 (3.2)</td>
<td>n = 269 6 (2.2)</td>
<td>n = 378 6 (1.6)</td>
<td>0.44</td>
</tr>
<tr>
<td>Diabetes, n (%)</td>
<td>n = 185 10 (5.4)</td>
<td>n = 269 24 (8.9)</td>
<td>n = 378 32 (8.5)</td>
<td>0.37</td>
</tr>
<tr>
<td>Tobacco use, n (%)</td>
<td>n = 182 25 (13.7)</td>
<td>n = 269 25 (9.3)</td>
<td>n = 378 29 (7.7)</td>
<td>0.72</td>
</tr>
<tr>
<td>Alcohol use, n (%)</td>
<td>n = 182 80 (44.0)</td>
<td>n = 269 115 (42.8)</td>
<td>n = 378 156 (41.3)</td>
<td>0.82</td>
</tr>
<tr>
<td>Fruits and Veg., met recommendation n (%)</td>
<td>n = 186 97 (52.2)</td>
<td>n = 269 152 (56.5)</td>
<td>n = 378 193 (51.1)</td>
<td>0.38</td>
</tr>
<tr>
<td>Frequently adds salt to food at the table, n (%)</td>
<td>n = 158 24 (13)</td>
<td>n = 269 35 (13)</td>
<td>n = 279 (12.4)</td>
<td>0.65</td>
</tr>
<tr>
<td>Frequently adds salt to cooking at home, n (%)</td>
<td>n = 185 149 (80.5)</td>
<td>n = 296 225 (83.6)</td>
<td>n = 378 291 (77)</td>
<td>0.05</td>
</tr>
<tr>
<td>Believe that they are eating just the right amount of salt n (%)</td>
<td>n = 185 105 (56.8)</td>
<td>n = 267 169 (63.3)</td>
<td>n = 376 228 (60.6)</td>
<td>0.18</td>
</tr>
<tr>
<td>Believe a high salt diet can cause a serious health problem, n (%)</td>
<td>n = 180 144 (80.0)</td>
<td>n = 259 207 (79.9)</td>
<td>n = 368 296 (80.4)</td>
<td>0.99</td>
</tr>
<tr>
<td>Does something to control salt consumption, n (%)</td>
<td>n = 183 82 (44.8)</td>
<td>n = 260 126 (48.5)</td>
<td>n = 363 182 (50.1)</td>
<td>0.50</td>
</tr>
</tbody>
</table>
Data are presented as median (IQR, interquartile range) unless otherwise stated. BMI, body mass index; hypertension prevalence, BP ≥ 140/90 or previous diagnosis; Current use of hypertension medication represents current use in the last two weeks; BMI, body mass index; tobacco use by self-report; alcohol use by self-report; met fruits and vegetable recommendation indicates consumed five or more servings of fruits and vegetables a day; salt behaviour responses, frequently indicates ‘always’ and ‘often’; continuous variables compared using Independent Kruskal-Wallis Test and categorical variables compared using Pearson Chi-Square Test and Fisher’s Exact Test. a, b, c; sig at p < 0.05.

In response to the salt behaviour questions (Supplementary Table 5.4), 12.8% (n = 107) of participants reported that they frequently (always and often) added salt to food at the table with significantly greater numbers of younger (27.3%, n = 28, p = 0.02) and rural (61%, n = 61, <0.01) dwellers responding affirmatively to this question. More than three quarters (80.1%, n = 671) of the surveyed population reported that they frequently added salt to food at home during cooking while 60.9% (n = 508) perceived themselves to consume the right amount of salt. While 19.9% (n = 126) did not know that a high salt diet could cause a serious health problem, 48.5%, (n = 394) of the participants reported actively doing something on a regular basis to control their salt intake. Of those who knew a high salt diet could cause a serious health problem, 58.9% (n = 378) did something on a regular basis to control their salt intake.

Almost two-thirds (65%, n = 548) of participants did not meet the daily K recommendation of ≥ 90mmol [27], with those in the lowest salt intake group having the lowest urinary concentrations. While 42.6% (n = 141) of urban participants met the guidelines for K intake, this was the case for only 28.6% (n = 101) of participants residing in rural areas (p < 0.01). Only 7.6% (n = 63) achieved the recommended Na: K ratio of ≤ 1mmol [27]. There was a strong positive correlation between 24hr urinary Na and K concentrations (Spearman’s rho = 0.71, p < 0.01). Linear regression indicated that urinary Na excretion accounted for more
than half the variability in urinary K excretion ($R^2 = 0.51$, $F (1, 832) = 861, p = <0.01$). Urinary K excretion increased by 0.71 mmol/day for each mmol/day increase in urinary Na such that Na:K ratio was significantly higher in the high salt group compared to the low salt group (median 2.3 (1.9) g/day vs 1.7 (1.9) g/day, respectively, $p < 0.01$).

The high Na:K group had a significantly higher BMI than those in the lowest Na:K group (median 28.1, IQR 8.2 vs 24.8, IQR 7.0, $p = 0.01$) and had higher number of participants who reported doing something on regular basis to control their salt intake than those in the lowest Na:K group (61.5%, $n = 15$ vs 42.7%, $n = 166$, $p < 0.01$) (Table 5.3).

Table 5.3 Nested cohort by urinary sodium to potassium (Na:K) ratio, low, medium and high groups, WHO – SAGE Ghana Wave 3 (2019).

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Low Na: K (&lt;2)</th>
<th>Medium Na: K (2–5)</th>
<th>High Na: K (&gt;5)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age yrs</td>
<td>60 (18)</td>
<td>61 (19)</td>
<td>58 (22)</td>
<td>0.44</td>
</tr>
<tr>
<td>Sex male n (%)</td>
<td>$n = 399$</td>
<td>$n = 389$</td>
<td>$n = 41$</td>
<td>0.29</td>
</tr>
<tr>
<td></td>
<td>139 (34.8)</td>
<td>116 (29.8)</td>
<td>12 (29.3)</td>
<td></td>
</tr>
<tr>
<td>Ethnicity (%)</td>
<td>$n = 397$</td>
<td>$n = 387$</td>
<td>$n = 41$</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Akan</td>
<td>229 (57.7)</td>
<td>246 (63.6)</td>
<td>17 (41.5)</td>
<td></td>
</tr>
<tr>
<td>Ga</td>
<td>5 (1.3)</td>
<td>29 (7.5)</td>
<td>10 (24.4)</td>
<td></td>
</tr>
<tr>
<td>Ewe</td>
<td>31 (7.8)</td>
<td>23 (5.9)</td>
<td>1 (2.4)</td>
<td></td>
</tr>
<tr>
<td>Mole-dagbon</td>
<td>13 (3.3)</td>
<td>11 (2.8)</td>
<td>0 (0.0)</td>
<td></td>
</tr>
<tr>
<td>Mole-busanga</td>
<td>2 (0.5)</td>
<td>1 (0.3)</td>
<td>0 (0.0)</td>
<td></td>
</tr>
<tr>
<td>Grusi</td>
<td>7 (3.0)</td>
<td>5 (1.3)</td>
<td>0 (0.0)</td>
<td></td>
</tr>
<tr>
<td>Guan</td>
<td>12 (3.0)</td>
<td>4 (1.0)</td>
<td>0 (0.0)</td>
<td></td>
</tr>
<tr>
<td>Gruma</td>
<td>3 (0.8)</td>
<td>3 (0.8)</td>
<td>0 (0.0)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>95 (23.9)</td>
<td>65 (16.8)</td>
<td>173 (41)</td>
<td></td>
</tr>
<tr>
<td>Urban (%)</td>
<td>$n = 398$</td>
<td>$n = 389$</td>
<td>$n = 41$</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td></td>
<td>183 (46.0)</td>
<td>240 (61.7)</td>
<td>26 (63)</td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td>$n = 253$</td>
<td>$n = 267$</td>
<td>$n = 26$</td>
<td>0.51</td>
</tr>
<tr>
<td></td>
<td>10 (4)</td>
<td>10 (5)</td>
<td>10 (6)</td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td>$n = 387$</td>
<td>$n = 364$</td>
<td>$n = 39$</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td>24.8 (7.0)</td>
<td>25.7 (7.4)</td>
<td>28.1 (8.2)</td>
<td></td>
</tr>
<tr>
<td>Salt intake g/d</td>
<td>$n = 398$</td>
<td>$n = 384$</td>
<td>$n = 40$</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td></td>
<td>7.5 (7.4)</td>
<td>8.6 (6.6)</td>
<td>13.9 (11.9)</td>
<td></td>
</tr>
<tr>
<td>K intake, mmol/d</td>
<td>$n = 399$</td>
<td>$n = 389$</td>
<td>$n = 41$</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Characteristics</td>
<td>Low Na: K (&lt; 2)</td>
<td>Medium Na: K (2 – 5)</td>
<td>High Na: K (&gt;5)</td>
<td>p value</td>
</tr>
<tr>
<td>-----------------------------------------</td>
<td>-----------------</td>
<td>---------------------</td>
<td>-----------------</td>
<td>---------</td>
</tr>
<tr>
<td>Characteristic</td>
<td>n = 399</td>
<td>n = 389</td>
<td>n = 41</td>
<td></td>
</tr>
<tr>
<td>Urinary iodine excretion, mmol/day</td>
<td>129.7 (116.0)</td>
<td>153.9</td>
<td>146.9 (193.9)</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Systolic BP, mm Hg</td>
<td>126 (26)</td>
<td>126 (32.0)</td>
<td>125 (34.0)</td>
<td>0.03</td>
</tr>
<tr>
<td>Diastolic BP, mm Hg</td>
<td>77 (17.0)</td>
<td>75 (17.0)</td>
<td>77 (18.0)</td>
<td></td>
</tr>
<tr>
<td>Pulse pressure, mm Hg</td>
<td>48 (16.6)</td>
<td>51 (17.0)</td>
<td>51.7 (15.0)</td>
<td>0.26</td>
</tr>
<tr>
<td>Mean Arterial Pressure (MAP), mm Hg</td>
<td>93.7 (18.8)</td>
<td>92.5 (21.2)</td>
<td>91.7 (25.3)</td>
<td>0.61</td>
</tr>
<tr>
<td>Hypertension Prevalence, n (%)</td>
<td>170 (42.7)</td>
<td>178 (46.0)</td>
<td>18 (45.0)</td>
<td>0.65</td>
</tr>
<tr>
<td>Hypertension awareness, n (% of hypertension prevalence)</td>
<td>102 (60.0)</td>
<td>106 (59.6)</td>
<td>11 (61.1)</td>
<td>0.10</td>
</tr>
<tr>
<td>AHT, current use (% of hypertension awareness)</td>
<td>65 (63.7)</td>
<td>79 (74.8)</td>
<td>7 (63.6)</td>
<td>0.22</td>
</tr>
<tr>
<td>Hypertension control, n (% of AHT)</td>
<td>33 (52.5)</td>
<td>40 (51.3)</td>
<td>3 (42.9)</td>
<td>0.89</td>
</tr>
<tr>
<td>Stroke, n (%)</td>
<td>11 (2.8)</td>
<td>7 (1.8)</td>
<td>0 (0.0)</td>
<td>0.45</td>
</tr>
<tr>
<td>Diabetes, n (%)</td>
<td>34 (8.5)</td>
<td>30 (7.7)</td>
<td>2 (4.9)</td>
<td>0.69</td>
</tr>
<tr>
<td>Tobacco use, n (%)</td>
<td>45 (11.3)</td>
<td>34 (8.7)</td>
<td>0 (0.0)</td>
<td>0.05</td>
</tr>
<tr>
<td>Alcohol use, n (%)</td>
<td>160 (40.1)</td>
<td>172 (44.2)</td>
<td>19 (46.3)</td>
<td>0.44</td>
</tr>
<tr>
<td>Fruits and Veg., met recommendation n (%)</td>
<td>212 (53.1)</td>
<td>203 (52.2)</td>
<td>24 (58.5)</td>
<td>0.74</td>
</tr>
<tr>
<td>Frequently add salt to food at the table, n (%)</td>
<td>52 (13)</td>
<td>48 (12.3)</td>
<td>6 (14.6)</td>
<td>0.88</td>
</tr>
<tr>
<td>Frequently add salt to cooking at home, n (%)</td>
<td>320 (80.0)</td>
<td>311 (79.9)</td>
<td>33 (80.5)</td>
<td>0.30</td>
</tr>
</tbody>
</table>
Data are presented as median (IQR, interquartile range) unless otherwise stated. BMI, body mass index; hypertension prevalence, BP ≥ 140/90 or previous diagnosis; AHT, antihypertensive medication use in the last two weeks; tobacco use by self-report; alcohol use by self-report; met fruits and vegetable recommendation indicates consumed five or more servings of fruits and vegetables a day; salt behaviour responses, frequently indicates ‘always’ and ‘often’; continuous variables compared using Independent Kruskal-Wallis Test and categorical variables compared using Pearson Chi-Square Test and Fisher’s Exact Test. a, b, c; sig at p < 0.05.

Excluding all participants on treatment for hypertension (n = 154), a Spearman’s rank order correlation showed no association between Na excretion, K excretion or Na: K ratio and SBP, DBP or PP. We also found no significant difference between the regression slopes of SBP, DBP or PP with age in low (<5g/d, n = 154, medium (5-9g/d, n = 220 and high (> 9g/d, n = 302) salt groups (Figure 2). However, there was an association between BP and the age regression slope according to urinary Na: K ratio. Compared with low Na: K ratio (<2) and medium Na: K (2-5) ratios, the high Na: K group (> 5) had a significantly steeper slope with age for both SBP and DBP (p = 0.01 and p < 0.01 respectively). No significant differences for the slopes in all three Na: K groups was found for PP (Figure 3). Among the high salt group (> 9g/d), univariate analysis showed a significant relationship between age, father’s education, diabetes, K and physical activity with SBP while sex, age and father’s education were associated with DBP.
Figure 5.2 Slope of systolic, diastolic, pulse pressure and MAP with age in low (<5 g/day, n = 154), medium (5–9 g/day, n = 220) and high (>9 g/day, n = 302) salt groups excluding those on bp medication.
Figure 5.2 Slope of systolic, diastolic and pulse pressure with age in low (< 2 mmol/mmol, n = 334), medium (2–5 mmol/mmol, n = 308) and high (> 5 mmol/mmol, n = 34) Na: K groups excluding those on bp medication.
5.4 Discussion

In a nationally representative sample of adult Ghanaians (50y and older), we report that 24hr urinary Na excretion equated to a median salt intake of 8.3g/day, with more than three-quarters of participants having salt intakes more than the WHO recommendation of <5g/day. This is considerably higher than median salt consumption values of 6.8g - 7.2g/day reported by recent studies from SA [28, 29], a country that has adopted mandatory salt reduction policies. Our data provides much-needed information required to inform strategies to meet the WHO global voluntary target for NCD prevention of 30% reduction in mean population intake of salt, with the aim of achieving a target of less than 5 grams per day by 2025 [8]. The only other available information on 24hr urinary Na excretion in Ghana was collected over a decade ago when salt intake was estimated to be 6.0g/day [30]. Over this time, the Ghanaian food environment has changed dramatically [31, 32] with the emergence of energy dense, nutrient poor, processed convenience foods such as instant noodles, salty snacks (e.g. potato, corn, and tortilla chips), visible fat (e.g. butter, margarine, oils, dressings and gravies), ready-made baked foods (e.g. cookies, cakes, pies and pastries), desserts such as puddings and cheesecake, and sweetened products (e.g. sugar, syrup, ice cream, candy, and carbonated and noncarbonated sweetened drinks). Additionally, frequent consumption of highly salted foods, such as fish and meat, remains part of the traditional Ghanaian cuisine, and salt use in cooking, remains high [30, 33].

It is noteworthy that more than three quarters of participants in the current study reported adding salt to food during cooking. Poor salt use behavior is widespread in the Ghanaian population; a previous study involving 12 villages in Ghana in 2006 reported that 98% of participants added salt to food during cooking, while about half (52%) added salt to food at the table [21]. In comparison to South Africans, Ghanaians reported adding salt to food during cooking more frequently [33], presumably because mass media public health campaigns to lower salt use, such as Salt Watch in SA have not yet occurred in Ghana [34]. Further, Ghana’s national salt iodization programme, along with accompanying major
public health campaigns on iodine consumption [35-38] may partially be responsible for an increase in discretionary salt intake. However, lack of information on sources of salt provided from discretionary and non-discretionary sources, as in processed foods, prevents further hypothesis in this regard.

Despite the current study not including a dietary assessment component, a recent systematic review of dietary sources of salt in LMICs identified that bread, meat and meat products, bakery products, instant noodles, salted preserved foods, milk and dairy products, and bouillon cubes were major sources thereof [39]. In some LMICs, bread alone may contain as much as 1.36g salt per 100g bread [40]. For many African countries, bread has become a staple food, such as in some regions of Democratic Republic of Congo, where bread has replaced cassava [41]. The nutrition transition taking place in Sub Saharan Africa and its transformation of dietary patterns from a reliance on traditional staples to an increased intake of energy dense, nutrient poor foods (and often Na rich) foods may partly be responsible for the observed high salt intake reported by this study. In support of this, the Ghana Demographic and Health Survey 2014 reported that more than a third (36%) of participants consumed salted dried fish [42], while in the Ghana National Iodine Survey Report 2015, consumption of bouillon cubes was frequent and widespread with nearly half (48.8%) of the participants having consumed this item at least 6 times a week [43].

Awareness of excessive salt intake was low in the current study. Sixty one percent of participants believed that they were meeting the salt recommendation guidelines, but only 22.3% achieved this. Estimations of dietary salt intake using dietary recall methods usually indicates a reduced daily intake compared to 24hr urinary collections [44-46]. The tendency to under-estimate salt consumption is high as many people are unaware of the recommendation for salt consumption, unable to determine the salt content of everyday foods such as bread and cereals, or that of composite meals [47-49]. In Ghana, there are no salt reduction strategies in place such as: mandatory or voluntary levels of salt permitted in processed foods; regulations for food labelling to indicate salt content in products, or front-of-pack signposting for high salt warnings. In addition, the Ghanaian food composition
tables are outdated and incomplete in the case of Na [50], making it difficult to assess food contributors to total salt intake. In view of this, regular monitoring and evaluation of the food environment and food consumption patterns are warranted.

Potassium excretion, although low (median 63.8mmol/day, IQR 74.8, 65% did not meet recommended daily intake of K), was higher than that reported by other studies in the region [28, 29]. The K content of the food items obtained from the 2010-2011 Ghana Food Balance Sheet indicated that K supply per capita per day was about 9,086mg/day (233mmol/day), approximately 2.6-fold larger than the WHO recommended level (>90mmol/day) with yams, cassava and plantains constituting the bulk of K supply [51, 52]. However, it is well known that food balance sheets represent apparent, rather than actual, food consumption.

Hypertension prevalence in the current study was high (50 yrs, 52.6%; 18-48yrs, 14.5%), with less than two thirds (60%) of participants classified as hypertensives being aware of the condition (i.e. diagnosed), of which 69.1 % were being treated with antihypertensive medication, half of which had BP levels considered to be controlled (< 140/90mm Hg). Surprisingly, we found no association between urinary Na, K or N:K ratio with BP in contrasts to findings from other comparable studies [53-55] but in agreement with others [28, 56]. A possible reason may be the day-to-day variability in salt intake, which results in a high intra-individual variability in urinary Na excretion. Furthermore, salt sentivity and obesity have also been identified to cause variations in BP levels to dietary salt intake, among African populations [57-60]. Though 24hr Na excretion is the gold standard method for determination of population Na intake, repeated 24hr collections over periods provide more accurate estimating an individual’s habitual salt intake [61, 62]. However, this approach is typically impractical for large population studies such as the one reported here.

Similarly, no difference was found between the slopes of SBP, DBP or PP with age according to three categories of salt intake, namely low (5g/day), medium (5-9g/day) and high (>9g/day). However, high and medium urinary Na: K had steeper slopes of BP with age as compared with those in the low Na: K category. A national survey (WHO-SAGE Wave 2,
SA) conducted in 2015 reported similar findings [28]. This association was first explored in the INTERSALT study, the largest multinational study on 24hr urinary excretion and BP with 10,079 adults across 48 centres worldwide [54]. This implies that a simultaneous increase in K and a decrease in Na will be beneficial in reducing BP with age and ultimately hypertension incidence [27, 54]. As such, strategies such as taxes on high-salt products, labelling and effective communication, voluntary salt commitments by food industries and legislations for Na reduction are warranted. Similarly, to increase K intake, nutrition promotion of K rich fruits and vegetables may be needed, along with policies that make these foods more accessible and affordable.

A strength of the study is the use of a large nationally representative sample of participants aged 50+ years, in keeping with the aim of WHO-SAGE studies. This design on the other hand, may limit generalization to the entire population. Another potential limitation is the recruitment strategy which resulted in more women than men. Women are known to be more likely to volunteer to participate in surveys than men [63] and this has been observed in other 24hr urine collection studies [28, 29]. Akan, the largest ethnic group in Ghana is well distributed over the entire country [42] which is why this group was proportionally larger than other ethnic groups in the sample. Additionally, the cross-sectional analysis limits the ability to evaluate the influence of dietary Na and K intake on BP over time. The choice of urine volumes as a sole determinant of completeness of 24 h urine collections require explanation. Presently, there is no universally accepted standard for determining completeness of 24 h urine collections. The International Consortium for Quality Research on Dietary Sodium/Salt (TRUE), recommends the use of para-aminobenzoic acid (PABA) as being the preferred method [64] but experiences using PABA in African communities is limited and experiences from South Africa [65] suggest that participants may forget or choose not to take their PABA tablets during the urine collection period, thus rendering this method impractical.

The TRUE consortium recognized a need to establish further additional measures of assessing 24 h urinary completeness beyond PABA. A systemic review found that no single
exclusion criteria (24 h urinary creatinine excretion, creatinine index < 0.7, total urinary volume, a combination of creatinine excretion and total urine volume or self-report of missing urine) appeared more accurate in identifying incomplete 24-h urine collections than any others [66]. Importantly, the authors point out that the use of a combination of methods such as creatinine excretion together with urinary volume may lead to the unnecessary exclusion of participants with complete urine samples. The reference values used as a cut-off for inadequate urinary collection based on creatinine values has largely been based on those recommended by Stolarz-Skrzypek et al., namely urinary volume < 300 ml, or creatinine excretion < 4 mmol or > 25 mmol for women and < 6 mmol and > 30 mmol for men [28]. The applicability of these creatinine excretion reference values across different ethnic groups has recently been questioned [66]. While the TRUE authors concluded that a creatinine index < 0.7 may best increase the sensitivity of eliminating incomplete urine sampling, they go on to promote the use of similar methodologies used by the INTERSALT and INTERMAP studies as the preferred method to determine 24 h urinary completeness in population-based studies [27, 67]. These were as follows: samples that fell outside of the collection time of 22–26 h; participants’ indication that the collection was incomplete and that they had spilled ‘more than a few drops’ of urine; or if total urinary volume was < 250 ml. Given that creatinine is generally variable and largely dependent on muscle mass and protein intake [62], and the reference cut-off values in African populations have not been widely validated, we opted to use 24 h urinary volumes ≤ 300 ml as the measure for incomplete collections. The generally low creatinine excretion values found across the entire cohort suggest a possible low dietary protein intake, but a lack of dietary data precludes further consideration in this regard.

5.5 Conclusions

This nationwide study of Ghanaians, using 24hr urinary collections, reported a high intake of salt, accompanied by a low K intake. Increasing urinary Na: K ratio was associated with increasing BP with age. Given the high prevalence of hypertension in the study, our findings
identify a need for population-wide strategies to reduce dietary salt intake whilst, at the same time, increase K intake in Ghana.

5.6 References


51. Food and Agriculture Organization. Food balance sheets: a handbook, Economic and Social Development Department, Food and Agriculture Organization of the United Nations, Rome, Italy.; 2012.


Chapter 6

Determinants of change in blood pressure in Ghana: WHO-SAGE Ghana Waves 1 – 3

This chapter highlights the change in BP, hypertension awareness, treatment and control over a period of 11-12y among the same participants. It also identifies the predictors of change in DBP and hypertension awareness.

This chapter is the substantive content of the published work:
Abstract

The prevalence of hypertension is increasing in low- and middle-income countries (LMICs), however statistics are generally derived from cross sectional surveys that utilize different methodologies and population samples. We investigated BP changes over 11-12 years in a nationally representative cohort of adults aged 50 years and older (n = 820) included in the World Health Organization’s Study on global AGEing and adult health (WHO-SAGE Ghana) Wave 1 (2007/8) with follow up in Wave 3 (2019). Participants’ BP were measured in triplicate and a survey completed at both time points. Survey instruments collected information on sociodemographic characteristics, lifestyle, health behaviors and chronic conditions. While no significant difference was found in systolic BP between Waves 1 and 3, diastolic BP decreased by 9.7 mm Hg (mean = 88.6, 15.4 to 78.9, 13.6 respectively) and pulse pressure (PP) increased by 9.5 mm Hg (44.8, 13.7 to 54.3, 14.1). Awareness of hypertension increased by 37%, from (20% to 57%), but no differences were found for the proportion of hypertensives receiving treatment nor those that had controlled BP. Mixed effects modelling showed a decrease in DBP was associated with increasing age, living in rural areas and having health insurance. Factors associated with an increased awareness of hypertension were residing in urban areas, having health insurance and increasing body mass index (BMI). While diagnosis of hypertension has improved over time in Ghana, there is an ongoing need to improve its treatment in older adults.

Keywords

Blood pressure, hypertension awareness, treatment, control, WHO-SAGE, Ghana
6.1 Introduction

An urgent need to reduce population level BP is recognized globally by health agencies and governments to minimize the associated outcomes of stroke, myocardial infarction, cardiac failure, dementia, renal failure, blindness and premature death [1-9]. A 25% relative reduction in the prevalence of raised BP by 2025 is one of the voluntary global targets of the World Health Organization (WHO) for prevention of NCDs, and resources have been developed to assist countries to achieve this target [9, 10]. However, progress towards this target has been slow, with hypertension remaining a major health challenge in many countries [9, 11-14].

Worldwide, population level BP has been declining particularly for high and middle-income regions while it has remained stable or has increased among low-income countries. In an extensive analysis of 1479 national, subnational and community studies conducted between 1975 and 2015 in 19·1 million participants, significant reductions in mean SBP and DBP over time were demonstrated (15). In a worldwide study, SBP decreased by 0.8mm Hg and 1 mm Hg per decade for males and females, respectively, between 1980 and 2008 with substantial reductions reported in Australia, Western Europe and North America [16]. However, increased SBP has been recorded in the Oceania, east Africa, and south and southeast Asia for both sexes, and in West Africa for women, ranging from an increase of 0·8-1·6 mm Hg in men and 1·0-2·7 mm Hg in women per decade [16]. Furthermore, studies examining BP across the life-course indicate that, while SBP typically increases continuously until age 70 or 80 years, DBP typically rises less steeply than SBP and remains constant or even declines after the fifth to sixth decade of life [17-21]. Consequently, an increased pulse
pressure (PP) poses a major cardiovascular risk [19, 22-24]. However, it remains unclear how changes with age in older adults in regions such as Sub-Saharan Africa (SSA) where population level BP is not declining. With high hypertension rates and low levels of awareness, treatment and control in the African region [25-29], understanding changes over time in older adults is essential in order to reduce associated morbidity and mortality.

To better understand the trajectory of hypertension and predictors of change in BP over time, we aimed to identify changes in population level BP in a nationally representative longitudinal cohort of Ghanaians over an 11-12 year period.

### 6.2 Methods

Details of the methodology has been described in chapter two. For the purpose of this analysis, data from participants included in WHO-SAGE W1 (2007/2008) were compared with those followed up in a preliminary analysis of data from W3 (2019). We followed up 820 participants with valid BP and self-reported hypertension status data from W1 to W3. The flow diagram (Fig. 1) demonstrates the selection procedure. We compared the 820 subjects (50+ y olds) included in this work with both the 3,904 (=4,724-820, aged 18+) participants excluded (i.e. not followed-up and not valid BP data) and the 79 (=899-820, aged 50+) subjects followed-up but with no valid BP data. Supplementary tables 2 and 3 (Appendix E) show the distribution of selected socio-demographic and health variables; all the frequencies were not weighted. The main study outcome for this analysis was BP. Characteristics of the participants presented in Table 6.1.
Data were analyzed using Stata Statistical Software: Release 16 (Stata Corp LLC, 2019; College Station, USA). Due to non-responses for some survey items, the number of responses (n) for each variable are included in the tables. The WHO-SAGE Ghana participants are allocated a unique 10-digit identifier code that facilitates linking of participant’s information over the two waves of the study. Categorical variables were compared using Chi square test while the Wilcoxon Signed Ranked Test was used to compare continuous variables in the cohort over time. Change in BP was calculated by subtracting the BP measurement obtained in WHO-SAGE W1 from that in WHO-SAGE W3. Nonparametric kernel-density plots were constructed with the kdensity command and the default Epanechnikov kernel function utilized. A kernel density plot is a smoothed representation of a histogram with the area under the curve representing the proportion of values compared to all values and sums to 1. Kernel density shows the probability density
estimates of the distribution. Mixed model effects regression modelling was used to assess potential predictors of the longitudinal changes in SBP and DBP between W1 and W3. This statistical method for repeated measurements accounts for correlations among measurements within an individual and variations across participants [30, 31]. Logistic regression was used to assess factors associated with change in hypertension awareness.

6.3.1 Results
Out of the total W1 sample (n = 5,573), 899 participants were aged 50y+ and were followed-up in W3. Of these, 820 respondents had complete data on BP and self-reported hypertension diagnosis.

Table 6. 1 Characteristics of participants in WHO-SAGE, Ghana W1 and W3 (n = 820)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Wave 1</th>
<th>Wave 3</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age in years</td>
<td>n = 820</td>
<td>n = 820</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td></td>
<td>59 (13)</td>
<td>71 (13)</td>
<td></td>
</tr>
</tbody>
</table>

School attendance

| Ever schooled, n (%)                     | n = 817      | n = 820      | < 0.001|
|                                         | 419 (51.3)   | 477 (58.2)   |        |

| Years educated for those who have ‘ever schooled’ | n = 390       | n = 427       | < 0.001|
|                                                  | 10 (4)       | 10 (7)       |        |

| Marital status: married/ cohabiting, n (%)      | n = 820      | n = 820      | < 0.001|
|                                                | 489 (59.9)   | 419 (51.1)   |        |

| Waist to height ratio (WtHR)                   | n = 815      | n = 747      | < 0.001|
|                                                | 0.51 (0.1)   | 0.53 (0.1)   |        |

| BMI                                             | n = 815      | n = 747      | < 0.001|
|                                                | 22.2 (5.9)   | 23.2 (7.1)   |        |

| Current alcohol use (%)                        | n = 820      | n = 820      | < 0.001|
| Never                                          | 376 (45.9)   | 452 (51.1)   |        |
| Current use                                    | 240 (29.3)   | 133 (16.2)   |        |
| Yes, but not current                           | 201 (24.5)   | 235 (28.7)   |        |

| Overall Physical Activity, n (%)               | n = 812      | n = 820      | < 0.014|
|                                                | 701 (86.3)   | 294 (53.9)   |        |
All data are presented as median (Interquartile range, IQR) unless otherwise indicated. Whereas walking/cycling refers to such activities completed in a typical week, overall physical activity represents all activities including vigorous, moderate, walking/cycling, vigorous fitness and moderate fitness completed in a typical week. Hypertension prevalence refers to BP ≥140/90 or self-reported treatment while hypertension awareness refers to self-reported diagnosis. Hypertension treatment denotes blood pressure medication use (within the last 2 weeks) prior to the survey and hypertension control represents medication use with a measured BP less than 140/90 mm Hg. Continuous variables were compared using Wilcoxon signed-rank test; categorical variables were compared using the Chi-Square test.

Out of the W1 sample (n = 5,110), 820 participants aged 50yrs+, had complete BP data at both W1 (median age, 59years) and W3 (median age, 71years) and were included in the analysis. The sample comprising 433 (52.8%) men and 387 women (47.2%), with 364 (44.4%) and 456 (56.6%) living in urban and rural areas, respectively. We further examined sociodemographic and cardiovascular related risk factors and found several changes. There

<table>
<thead>
<tr>
<th>Diabetes, n (%)</th>
<th>n = 820</th>
<th>n = 820</th>
<th>0.001</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>17 (2.1)</td>
<td>65 (7.9)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Depression, n (%)</th>
<th>n = 820</th>
<th>n = 820</th>
<th>0.645</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>13 (1.6)</td>
<td>13 (1.6)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Health Insurance, Yes n (%)</th>
<th>n = 820</th>
<th>n = 820</th>
<th>&lt; 0.001</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>307 (37.4)</td>
<td>706 (86.1)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SBP, mm Hg</th>
<th>n = 820</th>
<th>n = 820</th>
<th>0.783</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>131.0 (30.0)</td>
<td>130.5 (27.4)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DBP, mm Hg</th>
<th>n = 820</th>
<th>n = 820</th>
<th>&lt; 0.001</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>88.6 (20.5)</td>
<td>78.9 (18.0)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PP, mm Hg</th>
<th>n = 820</th>
<th>n = 820</th>
<th>&lt; 0.001</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>43.0 (16)</td>
<td>52.5 (17)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hypertension, n (%)</th>
<th>n = 820</th>
<th>n = 820</th>
<th>&lt; 0.001</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prevalence</td>
<td>426 (52.0)</td>
<td>400 (48.8)</td>
<td></td>
</tr>
</tbody>
</table>

| Hypertension awareness (% of hypertension prevalence) | 85 (20.0) | 228 (57.0) | < 0.001 |

| Hypertension treatment (% of hypertension awareness) | 66 (77.6) | 187 (82.0) | 0.101 |

| Hypertension control (% of hypertension treatment) | 18 (27.3) | 99 (52.9) | 0.195 |
was an increase in the proportion of participants reporting ever attended school which may reflect participation in adult learning literacy programmes in Ghana [32]. WtHR, BMI, diagnosis of diabetes and having voluntary health insurance increased in the cohort while current alcohol intake and overall physical activity levels decreased significantly between W1 and W3 (Table 6.1).

6.3.2 Blood pressure changes within the population
There was no difference in SBP between W1 and W3, however, a significant reduction of 9.7mm Hg W1, mean (SD) = 88.6 (15.4); W3, 78.9 (13.6) in DBP was observed over the 11-12 year follow up period. PP significantly increased by 9.4mm Hg (95% CI, W1 = 43.9-45.8; W3 = 53.3-55.2). Figures 6.1 and 6.2 graphically demonstrate that the distributions of SBP and DBP in both waves. While the curves are almost overlapping for SBP, the W3 distribution for DBP is clearly shifted to the left compared to W1.

Figure 6. 2 Non-parametric kernel-density estimates for the distribution of SBP (W1, W3 n = 820)
Figure 6.3 Non-parametric kernel-density estimates for the distribution of DBP (W1, W3 n = 820).

Hypertension prevalence decreased significantly by 3.2% over the period (W1, 52.0%, CI = 0.48-0.55; W3, 48.8%, CI = 0.45-0.52). Hypertension awareness increased by 37.0% (p < 0.01) over time with no differences observed for hypertension treatment nor the proportion of treated hypertensive participants that had controlled BP (Table 6.1). Fig 6.3 illustrates the distribution of hypertension prevalence, awareness, treatment and control in both waves by sex and age. There were significantly more women than men with hypertension in both waves. Hypertension prevalence was highest among the 50-59 year group in W1 (51.9%), who were aged 62-71 years in W3 (43.8%).
Figure 6. 4 Top left; hypertension prevalence (W1 n = 426, W3 n = 400), top right; hypertension awareness (W1 n = 95, W3 n = 245), bottom left; hypertension treatment (W1 n = 66, W3 n = 187), and bottom right; hypertension control (W1 n = 18, W3 n = 99).
6.3.3 Predictors of decrease in DBP and increase in awareness of hypertension
A mixed regression model that included change in DBP as the dependent variable found that the observed DBP decrease from W1 to W3 was associated with increasing age, living in rural areas, physical activity and having health insurance (Table 6.2). Predictors of change in prevalence of hypertension were increasing BMI and residing in rural areas (Supplementary Table 6.1). Female gender, ageing residing in rural areas, increasing BMI and having health insurance and diabetes predicted an increase in hypertension awareness over the two time periods (Table 6.3), adjusting for all variables.
Table 6.2 Multivariate analysis showing the predictors of decrease in DBP (WHO-SAGE Ghana Waves 1 and 3), n = 794

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Estimate</th>
<th>p-value</th>
<th>95% CI</th>
</tr>
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<tbody>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>Ref</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>-0.02</td>
<td>0.990</td>
<td>-3.415 - 3.19</td>
</tr>
<tr>
<td><strong>Age</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.19</td>
<td>&lt; 0.001</td>
<td>-0.30 - (-0.07)</td>
</tr>
<tr>
<td><strong>Location</strong></td>
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<td></td>
</tr>
<tr>
<td>Urban</td>
<td>Ref</td>
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<td></td>
</tr>
<tr>
<td>Rural</td>
<td>-3.98</td>
<td>&lt; 0.002</td>
<td>-5.97 - (-1.10)</td>
</tr>
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<td><strong>Marital Status</strong></td>
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<td></td>
</tr>
<tr>
<td>Married</td>
<td>Ref</td>
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<td></td>
</tr>
<tr>
<td>Not married</td>
<td>-2.36</td>
<td>0.933</td>
<td>-2.68 - 2.92</td>
</tr>
<tr>
<td><strong>Own education (yrs)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.30</td>
<td>0.04</td>
<td>-0.58 - (-0.01)</td>
</tr>
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<td><strong>Mothers education</strong></td>
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</tr>
<tr>
<td>Less than secondary school completed</td>
<td>Ref</td>
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<td></td>
</tr>
<tr>
<td>Secondary and above completed</td>
<td>-8.06</td>
<td>0.059</td>
<td>-16.41 - 0.29</td>
</tr>
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<td><strong>Fathers Education</strong></td>
<td></td>
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</tr>
<tr>
<td>Less than secondary school completed</td>
<td>Ref</td>
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</tr>
<tr>
<td>Secondary sch. and above completed</td>
<td>-1.20</td>
<td>0.477</td>
<td>-24.11 - 4.52</td>
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<td><strong>Health Insurance</strong></td>
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<td></td>
</tr>
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<td>No</td>
<td>Ref</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Characteristics</td>
<td>Estimate</td>
<td>p-value</td>
<td>95% CI</td>
</tr>
<tr>
<td>-----------------</td>
<td>----------</td>
<td>---------</td>
<td>-----------</td>
</tr>
<tr>
<td>Yes</td>
<td>-2.60</td>
<td>0.037</td>
<td>-5.03 - 40.16</td>
</tr>
<tr>
<td>BMI</td>
<td>0.03</td>
<td>0.359</td>
<td>-0.03 - 0.094</td>
</tr>
</tbody>
</table>

*Ever used alcohol*

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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<tbody>
<tr>
<td>No</td>
<td>Ref</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>0.81</td>
<td>0.34</td>
<td>-0.34 - 2.49</td>
</tr>
</tbody>
</table>

*Diabetes*

<p>| | | | |</p>
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<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>No</td>
<td>Ref</td>
<td></td>
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</tr>
<tr>
<td>Yes</td>
<td>0.31</td>
<td>0.878</td>
<td>-3.63 - 4.24</td>
</tr>
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</table>

*Ever used tobacco*

<p>| | | | |</p>
<table>
<thead>
<tr>
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<td>Ref</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>0.88</td>
<td>0.548</td>
<td>-1.99 - 3.76</td>
</tr>
</tbody>
</table>

| Overall physical activity | -2.65 | 0.030 | -5.03 - 0.25 |

Note: Ref represents reference category used for the comparison. Voluntary refers to contributors to health insurance who were not captured by the insurance scheme as public or civil service workers, while mandatory refers to contributors who were employees within the public, civil and private sectors. Overall physical activity represents all activities including vigorous, moderate, walking/cycling, vigorous fitness and moderate fitness completed in a typical week. Multivariate regression was adjusted for age, sex, marital status, years of education, mother’s education, father’s education, health insurance, diabetes and overall physical activity.
Table 6. 3 Odds Ratio showing the predictors of change in hypertension awareness (WHO-SAGE Ghana Waves 1 and 3), n = 369

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Hypertension Awareness</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OR (95% CI) p-value 95% CI</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>Ref</td>
</tr>
<tr>
<td>Female</td>
<td>1.98 0.021 1.10 - 4.450</td>
</tr>
<tr>
<td>Age</td>
<td>1.05 &lt;0.01 0.96 - 1.06</td>
</tr>
<tr>
<td>Location</td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>Ref</td>
</tr>
<tr>
<td>Rural</td>
<td>0.58 0.017 0.37 - 0.91</td>
</tr>
<tr>
<td>Marital status</td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>Ref</td>
</tr>
<tr>
<td>Not married</td>
<td>0.92 0.753 0.54 - 1.56</td>
</tr>
<tr>
<td>Years of education</td>
<td>0.01 0.589 0.96 - 1.10</td>
</tr>
<tr>
<td>Mothers education</td>
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</tr>
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<td>Less than secondary/high school completed</td>
<td>Ref</td>
</tr>
<tr>
<td>Secondary/high school and above completed</td>
<td>3.654 0.053 0.98 - 13.54</td>
</tr>
<tr>
<td>Fathers education</td>
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</tr>
<tr>
<td>Less than secondary/high school completed</td>
<td>Ref</td>
</tr>
<tr>
<td>Secondary/high school and above completed</td>
<td>0.60 0.644 0.63 - 4.32</td>
</tr>
<tr>
<td>Health Insurance</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>Ref</td>
</tr>
<tr>
<td>Yes</td>
<td>1.99 0.008 119. - 3.33</td>
</tr>
<tr>
<td>BMI</td>
<td>1.05 0.002 1.02 - 1.09</td>
</tr>
<tr>
<td>Diabetes</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>Ref</td>
</tr>
<tr>
<td>Characteristic</td>
<td>OR</td>
</tr>
<tr>
<td>----------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>Yes</td>
<td>74.29</td>
</tr>
<tr>
<td>Overall physical activity</td>
<td>1.44</td>
</tr>
</tbody>
</table>

Note: Ref represents reference category used for the comparison. Voluntary refers to contributors to health insurance who were not captured by the insurance scheme as public or civil service workers, while mandatory refers to contributors who were employees within the public, civil and private sectors. Overall physical activity represents all activities including vigorous, moderate, walking/cycling, vigorous fitness and moderate fitness completed in a typical week. Logistic regression was adjusted for age, sex, marital status, years of education, mother’s education, father’s education, health insurance, diabetes and overall physical activity.

6.4 Discussion

The main finding from this 12 year follow of older Ghanaians is an observed reduction in DBP accompanied by a reduction in hypertension prevalence. While no differences were recorded in SBP, there was a significant decrease DBP, accompanied by an increase in PP. DBP decreased for every age decile, with those aged 60-69 years at baseline having the greatest reduction over the period. A rise in hypertension awareness over the time was expected since older people are generally higher users of health services. Over the past decade, there has been an increased focus on hypertension screening activities [33] as well as heightened efforts from the health care system in Ghana to implement strategies to address NCDS [34-36]. It was not surprising that hypertension was higher among women than men due to the age of the cohort (50y+).

A lack of change in SBP between the two time periods is in contrast with many other studies that have reported a rise (18, 20, 21). This may however be explained by the age of the cohort in W3 (median, 71 years), and life expectancy in Ghana (64 years) [37]. Due to the median age of the cohort, survival bias could not be ruled out, however further investigation in this regard could not be conducted due to lack of access to information on cause and time of death. The observed decline in DBP with advancing age in this older cohort agrees with findings from other studies. A review on the epidemiology of hypertension indicated that
in most populations, DBP remained stable or reduced after age 50-60yrs [21]. Similarly, data from the Framingham Heart Study, which followed participants for three decades, showed that DBP varied with ageing, increasing until the fifth decade and gradually declining from age 60yrs onwards [20]. These age-related phenomena are explained by physiological changes in arterial structure and function. Aging is associated with an increased thickness of the arterial wall, nearly 3-fold between the ages of 20y and 90y, even in the absence of atherosclerotic plaques [38, 39]. An increase in the thickness of the arterial wall is accompanied by an increase in arterial stiffness [40] which in turn induces a decline in DBP [41,42-44]. The mechanism behind this decline is unclear, however, structural and molecular changes in the arteries (i.e. decreased elastin content, increased collagen I deposition and calcification) have been implicated [41-44]. Due to the fall in DBP and without any change in SBP in the current study, a reduction in hypertension prevalence was observed. However, this reduction should not be misconstrued to indicate a reduction in cardiovascular risk among the cohort. A longitudinal study that evaluated the risk of cardiovascular mortality emphasized that participants whose DBP decreased with unchanged SBP had a higher cardiovascular mortality compared to those whose SBP and DBP remained constant over time [45]. Similarly, Witteman et al. reported that, among females, a decline in DBP during a nine-year follow-up was associated with an enhancement of atherosclerotic lesions of the aorta, suggesting that a decline in DBP was a marker for atherosclerosis progression [46], reflecting prevailing compromise of the coronary circulation [42]. Hypertension is a known risk factor for atherosclerosis [47, 48]. Additionally, PP increased significantly due to the declining DBP in the current study, a situation that has the tendency to cause extensive damage to essential organs such as the brain and kidneys [41]. A large PP is associated with a greater risk for myocardial infarction, increased coronary disease and stroke even after effective BP control [23, 42, 49]. PP remains the most powerful independent predictor of cardiovascular risk in the elderly [18, 50].

The observed rise in hypertension awareness may reflect the older age of the participants who have experienced more engagement with health services over time, including routine measurement of BP at clinic visits. Other studies that included largely older participants
from Ghana, China, India and Mexico reported relatively higher hypertension awareness figures [25], compared to whole-of-population studies [51]. Despite the influence of advancing age, increasing hypertension awareness in the Ghanaian population could also be attributed to several health interventions and programmes that have been implemented by the Ghana Health Service (GHS) over the past 15-20 years. The government’s broader development plan was focused on Ghana achieving middle income country status by the year 2015, through various policies, such as the Ghana Poverty Reduction Strategies (2003–2005; 2006–2009); as well as those driven by the United Nations’ Millennium Development Goals, including the Ghana Shared Growth and Development Agenda, 2010–2013 [, 52-54]. Concurrent policies with varied mandates were also operationalized such as provision of community-based health planning and services (CHPs), which provided health information services preventive and curative care for chronic health conditions [55] and increased access to primary health care for particularly hard-to-reach communities [56]. In addition, the roll out of the national health insurance scheme in 2003 provided a major boost for services offered by CHPs and increased access to healthcare services in general, as clients were no longer required to provide out of pocket payments for some rendered healthcare services [34]. It is noteworthy that the current study reports of a dramatic increase in voluntary health insurance between W1 and W3. Along with CHPs, the Ministry of Health, in 2005, introduced the regenerative health and nutrition programme (RHNP) as part of its effort to curb the rising trend of NCDs [57] while in 2014, the ministry collaborated with Novartis Foundation to launch the community-based hypertension improvement program (ComHIP), which to date, conducts community-based BP screening and BP monitoring in many parts of the country [33]. The finding that more women were hypertensive than men was expected due to the biological changes that take place in women after menopause. Estrogen has been cited to cause endothelial vasodilation, inhibit sympathetic and renin-angiotensin system (RAS) activity, enhance the production of endothelin, reduce oxidative stress, increase antioxidant production and reduce inflammation - all of which regulate BP [58-60]. After menopause, estrogen levels fall causing an increase in hypertension [61-63].
The current study found that increasing age, residing in rural areas, increasing physical activity and having health insurance were associated with a reduction in DBP between W1 and W3. The assertion that BP increases with age has been established [64, 65], however age-related BP may differ according to individual circumstances. Our finding that living in a rural setting was associated with a decline in DBP is consistent with other studies conducted in Ghana. Data from the Ghana Demographic and Health Survey 2014 which surveyed 13,265 participants nationwide reported lower BP levels in rural compared to urban areas [66]. Similarly, sub-population studies conducted in Ghana have reported lower BP in rural residents compared to their urban counterparts [67, 68]. However, contrasting findings have been reported in other recent African-based comparison studies, indicating a rising BP in rural settings [69-71]. The finding that increasing physical activity is associated with BP reduction is well known (72, 73). In terms of dose-relationship, engagement in more regular and frequent physical activity results in greater reductions in BP irrespective of age, sex or ethnicity [74, 75]. Increased awareness of hypertension was associated with ageing, female gender, higher BMI, diabetes and having health insurance in the current study. Women were about 2 times more likely than men to be aware of their hypertensive status in the current study. This may be expected as women are known to generally have more interaction with clinics and hospitals through maternal and child health programmes and are known to place more importance on healthcare than men [76]. Furthermore, the sociocultural context (where men who sought healthcare were seen as feminine, vulnerable or weak) [77, 78] may be a disincentive for health-seeking behaviours in men. Increasing BMI predicted hypertension awareness. This association can be attributed to the higher incidence of hypertension among obese individuals compared to those with ‘healthy weight’ [79, 80]. Increasing body weight is a growing concern in Ghana [81] and a major modifiable cardiovascular risk factor [27]. Those having diabetes were about 7 times more likely to be aware of their hypertensive status than non-diabetics in the current study. Similarly, odds of hypertension awareness among diabetics have been reported (27, 82). Hypertension is a known risk factor for diabetes (90) and the two conditions mostly coexist.
As such, Ghana has introduced clinics in open food markets specifically for diabetes and which simultaneously offers opportunity for BP monitoring.

It was not surprising that having health insurance was associated with a decrease in DBP and an increase in hypertension awareness in the current study. The National Health Insurance Scheme (NHIS) which provides universal access to health care, has over the years improved in its efficiency and increased the range of healthcare services it covers, particularly among those of the lowest socioeconomic status and those most vulnerable groups in the population [85]. The number of outpatient visits increased sharply and health-seeking behaviour was enhanced as a result of the NHIS roll out [86, 87]. As of 2014, the NHIS had 40% coverage of Ghana’s population, an increment of 6.3% from 2010 [88, 89]. The NHIS’s widened access to most healthcare facilities in Ghana may have been an enabling factor in increase in hypertension awareness.

A major strength of the current study was the prospective design that allowed follow up of the same participants in two large nationally representative studies of persons aged 50 years and older using the same study design and methodology. Validity of data was achieved using extensively trained teams of interviewers that used standard protocol and instruments and inherent quality control measures. Limitations were the high rate of loss to follow up and the inability to generalize the findings over the entire population because of the higher age of the cohort.

6.5 Conclusions

Despite a reduction in DBP recorded between WHO-SAGE Ghana W1 and W3 (2007-2019), hypertension prevalence in W3 remained high. An increase in awareness of hypertension over this time period suggests improved health services for BP monitoring, but this was not accompanied by an increase in the proportion of hypertensive participants who were receiving treatment for the condition, nor improved BP control. Factors associated with a reduction in DBP included increasing age, residing in a rural area and having health insurance, while predictors of hypertension awareness included higher BMI and having
voluntary health insurance. This data suggests that existing health programmes should be intensified to improve the management of hypertension in Ghana.

6.6 References


34. National Community-Based Health Planning and Policy. 2016.


44. Alastair J, Webb S. Progression of arterial stiffness is associated with midlife diastolic blood pressure and transition to late-life hypertensive phenotypes. Journal of the American Heart Association 2020, 9. https://doi.org/10.1161/JAHA.119.014547


Chapter 7

Salt reduction strategies may compromise salt iodisation programmes: Learnings from South Africa and Ghana

This chapter discusses salt reduction in relation to its impact on iodine intake. The chapter emphasizes the importance of population salt reduction but, at the same evaluates its effect on dietary iodine in Ghana and SA - these countries have adopted and effectively implemented the universal salt iodization (USI) programme. With SA having successfully implemented a salt reduction legislation, and Ghana without, the chapter compares iodine intakes across salt categories in Ghana and SA.

This chapter is the substantive content of the published work:
Abstract

Universal salt iodization (USI) has been adopted by many countries to address iodine deficiency. More recently, salt reduction strategies have been widely implemented to meet global salt intake targets of <5g salt/day. Compatibility of the two policies has yet to be demonstrated. This study compares urinary iodine excretion (UIE) according to 24hr urinary Na excretion, between SA and Ghana, both with implemented USI, but Ghana without salt reduction legislation. Participants from World Health Organization’s (WHO) Study on global AGEing and adult health Wave 3 (2019), with survey and valid 24-hour urinary data (Ghana, n = 495; SA, n = 707) comprised the sample. Median 24-hour UIE was compared across salt intake categories <5, 5–9 and >9g/day. In Ghana, median Na excretion indicated a salt intake of 10.7g/day (IQR 7.6), while median UIE was 182.4 µg/l (IQR 162.5). In SA, salt and iodine values were lower (median salt 5.6g/day (IQR 5.0); median UIE 100.2 µg/l (IQR 129.6)). UIE differed significantly across salt intake categories (p<0.001) in both countries but in opposite directions. In Ghana, a weak correlation (r = 0.1501, p < 0.0011) was observed, compared to a moderate, positive association in SA (r = 0.4050, p < 0.0001). Participants with salt intakes <5g/day in SA did not meet WHO’s recommended iodine intake of 150µg/day, but this was not the case in Ghana. Monitoring and surveillance of iodine status is recommended in countries that have introduced salt reduction strategies in order to prevent re-emergence of iodine deficiency.

Key words: iodized salt, salt intake, legislation, sodium, Ghana, South Africa

7.1 Introduction

Iodine deficiency disorders remain a major global health issue affecting nearly 2 billion people worldwide, placing them at risk of irreversible brain damage and cognitive impairment. Iodine deficiency causes thyroid dysfunction and is implicated in psychomotor and developmental problems in its mild forms, and cretinism in its most severe form [1]. Populations residing in areas affected by severe ID may exhibit learning difficulties, particularly in children born to women who were iodine deficient whilst pregnant [2].
The World Health Organization (WHO) in 1991, attempted to address ID as a public health concern by recommending universal salt iodization (USI). As such, many countries have made excellent progress towards achieving the targets of IDD elimination [3].

Ghana launched its USI in 1995 in response to a nationwide survey conducted in 1994, which reported that IDD was endemic in almost half of the 110 districts of the country [4]. Following the adoption of USI, household access to iodized salt fluctuated in the 20 years that followed [4-6]. Recent studies among Ghanaian school aged children (6-12yrs) and pregnant women have reported a median urinary iodine concentration (UIC) of 202μg/L and 155μg/L respectively, indicating adequate iodine intake [7, 8].

Similarly, in SA, low access to iodized salt by much of the population [9] led to implementation of a mandatory salt iodisation programme in 1995 [10]. Following an intensive mass education and health promotion programme related to iodine intake, improved coverage and usage of iodized salt was recorded in the 2005 national survey with a 15% increase in number of households using iodized salt and a median UIC of 215 μg/L and 177 μg/L for school children and adult women, respectively. However, since that time, no further national surveys have been conducted to assess iodine status in SA [11]. South Africa’s mandatory salt legislation introduced in 2016, in response to WHO’s voluntary target of < 5g salt per day, may have implications for the adequacy of iodine intake because of reductions in iodized salt used in processed foods and changes in salt use behaviours [12-14], but this is yet to be investigated.

Given that both Ghana and SA have national salt iodization programmes, but only SA has implemented mandatory salt legislation, a comparison of salt and iodine intake between these two countries provides an opportunity to investigate the impact of the salt legislation on iodine intakes in South Africans, using Ghana as a comparator country. It will provide an updated evaluation of the effectiveness of the salt iodization programmes in both countries. The aim of this study was to compare urinary iodine excretion across urinary Na excretion categories in an adult population from both Ghana and SA.
7.2 Methods

Details of the methodology have been described in chapter two. Specific to this chapter, a total of 6,973 participants were recruited for the main WHO-SAGE cohort (Ghana; n = 4,449, SA; n = 2,2524) out of which 5,756 that had valid data (Ghana, n = 3,548; SA, n = 2,208) were selected using the criteria of urine volume ≥300ml/day and creatinine concentration of ≥3mmol/day [15] and if corresponding survey data were available. Figure 7.1 provides details of the main sample and the nested sub study for both countries.

Sodium (mmol/l) in the 24 h urine sample was converted to salt intake (g/day) and categorised according to low (<5 g/day), medium (5-9 g/day) or high (>9 g/day) salt intakes, and iodine metrics investigated between these categories. To convert urinary excretion values to estimated daily iodine intake (μg/day), urinary iodine excretion (UIE; μg/24h) was divided by 0.92, based on the assumption that approximately 92% of dietary iodine is excreted in urine. A median UIC of <100μg/l indicates population-level deficiency [16].
Figure 7.1 Flow diagram

Ghana main cohort
N=4449 respondents interviewed

Ghana nested cohort
N=1121 24hr urine samples collected

SA main cohort
N=2524 respondents interviewed

SA nested cohort
N=1189 24hr urine samples collected

N=957 common subjects (main+nested)
N=586 with valid urine measurement (cut-off: Volume≥300ml & creatinine ≥3 mmol/24hrs)

Excluded:
- 164 urine data only
- 477 no age recorded
- 439 invalid urine

N = 3053 main cohort
N = 495 main + nested cohort

N=876 common subjects (main+nested)
N=887 with valid urine measurement (cut-off: Volume≥300ml & creatinine ≥3 mmol/24hrs)

Excluded:
- 313 urine data only
- 148 no age recorded
- 169 invalid urine

N = 1501 main cohort
N = 707 main + nested cohort
Estimated iodine intake values and UIE analyses were compared across three categories of 24-hour urinary Na values, equivalent to salt intakes of <5g/day, 5–9g/day and >9g/day. Normality of data was checked by visual inspection of histograms and the Shapiro-Wilk test. Categorical variables were evaluated using absolute numbers (percentages), Chi square and Fisher’s Exact tests while the Mann Whiney U and Kruskal-Wallis tests explored differences between groups for non-parametric data. Spearman’s ranked order correlations was used to ascertain the relationship between iodine concentrations and estimated salt intake, body mass index (BMI) and weight. Pearson correlation coefficient was calculated between log-transformed UIE and estimated salt intake. Data were analyzed using Stata Statistical Software: Release 16 (Stata Corp LLC, 2019; College Station, USA).

7.3 Results

Out of 2,310 participants who provided urine samples, 52% (n = 1202) who had both valid urine and survey data and were included in the sample. The sociodemographic characteristics of the subsample is compared with the main survey sample. Whereas the SA subsample had significantly older participants than in its remaining main survey, the Ghana subsample had a significantly higher proportion of younger participants than in its remaining main survey. Waist to height ratio and diabetes were significantly higher in the subsamples than in the main surveys in both countries. In Ghana, median UIE was 182.4 μg/ day (IQR 162.5), equivalent to median UIC of 137.3μg/l, while median salt intake was 10.7g/day (IQR 7.6). In the SA subsample, median UIE was much lower at 100.2 µg/day (IQR 129.6), equivalent to median UIC of 90.2μg/l, and accompanied by a lower median salt intake of 5.6g/day (IQR 5.0). There were no significant differences in UIE according to sex or age category (50+ yrs and 18-49yrs) in both countries. In the lowest salt category of <5g/day, UIE indicated suboptimal iodine intake among the SA subsample (72.4µg/l, IQR 75.6) but in Ghana, this was adequate (UIE 135.2μg/l, IQR 102.7) (Tables 1 and 2). A trend was observed for a decrease in UIE associated with increasing salt intake in the Ghana while in contrast, UIE significantly increased with increasing salt intake in the SA. (Fig 7.2). Weak correlations were found between UIE and salt intake in the Ghana subsample (r = 0.1501, p
<0.0011) while moderate correlations were found in the SA subsample (r = 0.4050, p < 0.0001) (Fig 7.2).
Table 7.1 Urinary iodine, estimated iodine intake and sodium excretion values by salt intake equivalent categories, SAGE South Africa W3.

<table>
<thead>
<tr>
<th></th>
<th>All (n=707)</th>
<th>Salt &lt;5g/day (n=313)</th>
<th>Salt 5-9 g/day (n=233)</th>
<th>Salt &gt;9 g/day (n=161)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium (mg/day)</td>
<td>2171.4 (1958.9)</td>
<td>1270.5 (646.8)</td>
<td>2564.1 (716.1)</td>
<td>4550.7 (1570.8)</td>
<td>0.0001</td>
</tr>
<tr>
<td>Salt (g/day)</td>
<td>5.6 (5.0)</td>
<td>3.3 (1.7)</td>
<td>6.6 (1.8)</td>
<td>11.7 (4.0)</td>
<td>0.0001</td>
</tr>
<tr>
<td>UIC (µg/L)</td>
<td>90.2 (107.2)</td>
<td>79.3 (96.8)</td>
<td>95.3 (100.7)</td>
<td>112.5 (126.6)</td>
<td>0.0001</td>
</tr>
<tr>
<td>UIC &lt; 50 µg/L, n(%)</td>
<td>165 (23.7)</td>
<td>93 (30.3)</td>
<td>40 (17.4)</td>
<td>32 (20.0)</td>
<td>0.001</td>
</tr>
<tr>
<td>24-hour UIE (µg/day)</td>
<td>100.2 (129.6)</td>
<td>72.4 (75.6)</td>
<td>117.3 (124.2)</td>
<td>170.8 (200.7)</td>
<td>0.0001</td>
</tr>
<tr>
<td>Estimated iodine intake (µg/day)*</td>
<td>108.9 (140.8)</td>
<td>78.7 (82.1)</td>
<td>127.5 (135.0)</td>
<td>185.7 (218.1)</td>
<td>0.0001</td>
</tr>
<tr>
<td>% with daily iodine intake below EAR for iodine (95 µg/day), n (%)</td>
<td>302 (43.3)</td>
<td>186 (60.6)</td>
<td>79 (34.4)</td>
<td>37 (23.1)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Frequently add salt to food at table, n(%)</td>
<td>108 (15.3)</td>
<td>46 (14.7)</td>
<td>39 (16.7)</td>
<td>23 (14.3)</td>
<td>0.745</td>
</tr>
<tr>
<td>Frequently add salt to food during cooking, n(%)</td>
<td>460 (65.1)</td>
<td>199 (63.6)</td>
<td>158 (67.8)</td>
<td>103 (64.0)</td>
<td>0.559</td>
</tr>
<tr>
<td>Believe they consume too much salt, n(%)</td>
<td>59 (8.6)</td>
<td>30 (9.9)</td>
<td>19 (8.4)</td>
<td>10 (6.3)</td>
<td>0.417</td>
</tr>
<tr>
<td>Believe a high salt diet is bad for health, n(%)</td>
<td>506 (81.6)</td>
<td>230 (81.9)</td>
<td>165 (80.5)</td>
<td>111 (82.8)</td>
<td>0.853</td>
</tr>
<tr>
<td>Regularly control of salt intake, n(%)</td>
<td>255 (42.7)</td>
<td>114 (42.9)</td>
<td>83 (42.6)</td>
<td>58 (42.7)</td>
<td>0.998</td>
</tr>
</tbody>
</table>

Data are presented as median (interquartile range; IRQ) unless otherwise indicated. Continuous variables compared using independent samples Kruskal-Wallis test. *Daily iodine intake assumed as 24-hour UIE (µg/day)/0.92 to account for biovariability. UIC: Urinary Iodine Concentration; UIE: Urinary Iodine Excretion; EAR: Estimated Average Requirement.
Table 7. 2 Urinary iodine, estimated iodine intake and sodium excretion values by salt intake equivalent categories, SAGE Ghana W3.

<table>
<thead>
<tr>
<th></th>
<th>All (n=492)</th>
<th>Salt &lt;5g/day (n=45)</th>
<th>Salt 5-9 g/day (n=140)</th>
<th>Salt &gt;9 g/day (n=307)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium (mg/day)</td>
<td>4163.5 (2980.8)</td>
<td>1573.1 (435.9)</td>
<td>2777.4 (747.6)</td>
<td>5447.7 (3646.6)</td>
<td>0.0001</td>
</tr>
<tr>
<td>Salt (g/day)</td>
<td>10.7 (7.6)</td>
<td>4.0 (1.1)</td>
<td>7.1 (1.9)</td>
<td>14.0 (9.3)</td>
<td>0.0001</td>
</tr>
<tr>
<td>UIC (µg/L)</td>
<td>137.3 (136.9)</td>
<td>184.9 (204.6)</td>
<td>164.5 (131.4)</td>
<td>118.9 (130.3)</td>
<td>0.0001</td>
</tr>
<tr>
<td>UIC &lt; 50 µg/L, n(%)</td>
<td>42 (8.9)</td>
<td>0</td>
<td>3 (2.2)</td>
<td>39 (13.2)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>24-hour UIE (µg/day)</td>
<td>182.4 (162.5)</td>
<td>135.2 (102.7)</td>
<td>172.5 (187.4)</td>
<td>200.6 (180.4)</td>
<td>0.0002</td>
</tr>
<tr>
<td>Estimated iodine intake (µg/day)*</td>
<td>198.3 (176.6)</td>
<td>146.9 (111.6)</td>
<td>187.4 (155.7)</td>
<td>218.1 (196.1)</td>
<td>0.0002</td>
</tr>
<tr>
<td>% with daily iodine intake below EAR for iodine (95 µg/day), n (%)</td>
<td>55 (11.6)</td>
<td>9 (21.4)</td>
<td>20 (14.9)</td>
<td>26 (8.8)</td>
<td>0.025</td>
</tr>
<tr>
<td>Frequently add salt to food at table, n(%)</td>
<td>58 (11.7)</td>
<td>4 (8.9)</td>
<td>13 (9.3)</td>
<td>41 (13.4)</td>
<td>0.381</td>
</tr>
<tr>
<td>Frequently add salt to food during cooking, n(%)</td>
<td>399 (80.6)</td>
<td>40 (88.9)</td>
<td>119 (85.0)</td>
<td>237 (77.2)</td>
<td>0.051</td>
</tr>
<tr>
<td>Believe they consume too much salt, n(%)</td>
<td>48 (9.7)</td>
<td>7 (15.6)</td>
<td>8 (5.7)</td>
<td>33 (10.8)</td>
<td>0.096</td>
</tr>
<tr>
<td>Believe a high salt diet is bad for health, n(%)</td>
<td>378 (78.3)</td>
<td>34 (77.3)</td>
<td>107 (79.3)</td>
<td>236 (78.4)</td>
<td>0.958</td>
</tr>
<tr>
<td>Regularly control of salt intake, n(%)</td>
<td>235 (48.9)</td>
<td>15 (33.3)</td>
<td>75 (55.1)</td>
<td>143 (48.1)</td>
<td>0.038</td>
</tr>
</tbody>
</table>

Data are presented as median (interquartile range;IQR) unless otherwise indicated. Continuous variables compared using independent samples Kruskal-Wallis test. *Daily iodine intake assumed as 24-hour UIE (µg/day)/0/92 to account for biovariability. Urinary Iodine Concentration; UIE: Urinary Iodine Excretion; EAR: Estimated Average Requirement.
7.4. Discussion

Our study found that in a sample of SA adults surveyed after introduction of a salt reduction policy, those with low salt intakes (<5g salt/day) had inadequate iodine intakes but however this was not observed in the sample of Ghanaian adults, using 24hr UIE as a biomarker of intake. Conversely, South Africans with high salt intakes (>9g/day) had optimal iodine intakes, but Ghanaians with high salt intakes had suboptimal iodine intakes. This data suggests that, in Ghana, people who are consuming high amounts of salt may be using non-iodized salt or salt that is not adequately iodized [17], whereas in SA, the strategies being
used for salt reduction, including the mandatory salt targets for processed food may be resulting in inadequate consumption.

Table 7. 3 Spearman’s rank-ordered and partial correlations between 24-hour urinary iodine concentration, estimated salt intake and body size, WHO-SAGE W3, SA.

<table>
<thead>
<tr>
<th>Correlation with 24-hour urinary iodine concentration (µg/day);</th>
<th>All (n=697)</th>
<th>Man (n=216)</th>
<th>Women (n=481)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salt intake (g/day)</td>
<td>r 0.4050</td>
<td>0.4166</td>
<td>0.3999</td>
</tr>
<tr>
<td></td>
<td>p &lt;0.0001</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>BMI (Kg/m²)</td>
<td>r 0.0210</td>
<td>0.1227</td>
<td>-0.0081</td>
</tr>
<tr>
<td></td>
<td>p 0.5944</td>
<td>0.0859</td>
<td>0.8641</td>
</tr>
<tr>
<td>Weight (Kg)</td>
<td>r 0.0425</td>
<td>0.1684</td>
<td>0.0103</td>
</tr>
<tr>
<td></td>
<td>p 0.2736</td>
<td>0.0161</td>
<td>0.8263</td>
</tr>
<tr>
<td>Waist circumference (cm)</td>
<td>r 0.0460</td>
<td>0.0156</td>
<td>0.0561</td>
</tr>
<tr>
<td></td>
<td>p 0.2481</td>
<td>0.8304</td>
<td>0.2416</td>
</tr>
<tr>
<td>Hip circumference (cm)</td>
<td>r -0.0319</td>
<td>-0.0008</td>
<td>-0.0439</td>
</tr>
<tr>
<td></td>
<td>p 0.4429</td>
<td>0.9914</td>
<td>0.3882</td>
</tr>
</tbody>
</table>

Correlations between iodine and body size controlled for salt intake.

Table 7. 4 Spearman’s rank-ordered and partial correlations between 24-hour urinary iodine concentration, estimated salt intake and body size, SAGE Ghana W3.

<table>
<thead>
<tr>
<th>Correlation with 24-hour urinary iodine concentration (µg/day)</th>
<th>All (n=471)</th>
<th>Man (n=162)</th>
<th>Women (n=309)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salt intake (g/day)</td>
<td>R 0.1501</td>
<td>0.1494</td>
<td>0.1460</td>
</tr>
<tr>
<td></td>
<td>P 0.0011</td>
<td>0.0678</td>
<td>0.0102</td>
</tr>
<tr>
<td>BMI (Kg/m²)</td>
<td>R 0.1051</td>
<td>-0.0266</td>
<td>0.1768</td>
</tr>
<tr>
<td></td>
<td>P 0.0254</td>
<td>0.7421</td>
<td>0.0023</td>
</tr>
<tr>
<td>Weight (Kg)</td>
<td>R 0.1191</td>
<td>0.0136</td>
<td>0.1704</td>
</tr>
<tr>
<td></td>
<td>P 0.0107</td>
<td>0.8655</td>
<td>0.0030</td>
</tr>
<tr>
<td>Waist circumference (cm)</td>
<td>R 0.1595</td>
<td>0.1353</td>
<td>0.1873</td>
</tr>
<tr>
<td></td>
<td>P 0.0006</td>
<td>0.0922</td>
<td>0.0012</td>
</tr>
<tr>
<td>Hip circumference (cm)</td>
<td>R 0.1466</td>
<td>0.0709</td>
<td>0.2030</td>
</tr>
<tr>
<td></td>
<td>P 0.0019</td>
<td>0.3790</td>
<td>0.0005</td>
</tr>
</tbody>
</table>

Correlations between iodine and body size controlled for salt intake.
Data from a sub study of WHO-SAGE SA Wave 2 [14] that were collected immediately prior to implementation of the salt legislation in 2016; by which time some manufacturers may have already reformulated their products [18], supports the current finding. The impact of the SA salt legislation on consumption of iodine has not been thoroughly investigated to date [19], and with more stringent salt restrictions that came into effect in June 2019 [20], adverse consequences on iodine intake of the population needs to be carefully monitored. Fortification levels of iodine in salt may need to be revised accordingly. Based on the current policy that mandates iodization of table salt, the results could be interpreted that, those in the highest category of salt intake may have been using more table salt (iodised) thus contributing to higher iodine intakes but lack of dietary data limits further interpretation. It has previously been reported that despite manufacturers not being required by law to use iodized salt in processed foods (only table salt falls under the legislation), commercial use of iodized salt in processed food production is common. Significant amounts of iodine were detected in a third of foods surveyed, and these were common brands of bread, margarine and salty snack flavourings [21]. If food manufacturers have previously used iodized salt in food processing, then salt reduction legislation may inadvertently reduce population salt iodine [19].

In relation to Ghana, the finding that, participants who had high salt intakes also had low iodine intakes, might be explained considering salt use behaviours. Previous studies have reported that salt intake in Ghana is high, and that only a third of households nationwide had access to sufficiently iodized cooking or table salt [, 17, 22,]. The 2014 Ghana Demographic and Health Survey also indicated that 36.6% of women and children live in environments with no iodized salt [23], and only 4 in 10 households consumed salt with adequate iodine [24]. Additionally, traditional eateries (i.e. informal eating places outside the home called ‘chop bars’) are popular in Ghana [25], however, a good number of these tend not to use iodized salt in their meal preparation [26]. The potential widespread use of non-iodized salt in Ghana is a practice that requires monitoring as it poses a major setback to effectiveness of the USI programme. Our data supports findings from surveys that have
reported widespread availability non-iodized salt in Ghana, that is related, in part, to relative affordability of iodized salt and consumer low education on the importance of using iodized salt [19, 27-29]. Findings from the Ghana Iodine Survey (GIS) indicated that half of all households in the south-salt-producing areas and approximately half of households in the mid region of Ghana were accessing salt with no added iodine, thus violating the Public Health Amendment Law 2012 Act 851 [17, 30]. Only 8.6% of the national sample of households were using salt with iodine levels in the WHO recommended range of 15-40ppm for household salt, suggesting that production methods for salt iodisation, may have been compromised [17, 31]. Chemical analysis of the iodine content in 11 most popular brands of iodized salt in Ghana indicated that, only 3 brands met recommended 50ppm of iodine at retail [32]. Both household and market surveys also reported that low availability and high cost of adequately iodized salt were deterrents to accessing the commodity [29]. In the current study, despite known inadequacies in the salt iodisation programme in Ghana, median UIE was considerably higher than in SA. Other sources of iodine warrants consideration.

Our study found that median salt intake was considerably lower in the SA sample compared to the Ghana sample as expected because of salt legislation for maximum salt levels permitted in processed foods [19] and other national health promotion programmes to reduce discretionary salt intake, such as Salt Watch [33]. The high morbidity and mortality associated with noncommunicable diseases [34], has resulted in many countries embarking on salt reduction interventions to reduce hypertension and cardiovascular disease [35], however such strategies do not exist in Ghana. The current analysis is supported by data from both WHO-SAGE SA Wave 2 [14] that raised concern that salt reduction strategies may adversely affect iodine consumption. However, other studies provide conflicting results [36, 37]. A previous study in South African adults in 2004, reported no difference in median urinary UIC across salt intakes categories [13]. Reasons are unclear but at that time, it was assumed that the predominant use of non-iodized salt in the production of processed food products resulted in lack of a difference in iodine across a range of salt intakes. Additionally,
national data collected in 2002 showed that 37.3% of households in SA used non-iodized salt at home [38].

Our findings highlight a need for health authorities in Ghana and SA to continually monitor both salt and iodine intakes in order to adjust salt iodization levels as required, to ensure the compatibility of salt iodisation and salt reduction strategies [39]. Monitoring of salt iodization at any point along the food supply chain (i.e. production, packaging, storage, retail outlets and homes) is key in ensuring efficacy of salt iodisation. Greater advocacy efforts are required to result in implementation of healthy food environment polices geared towards the prevention of nutrition related-noncommunicable disease (NCDs) in Ghana. An analysis of 41 food environment policies investigated in the country rated 75% of all good practice indicators as ‘low’ [40].

It is also timely for SA to reconsider iodine levels in table salt [41, 42] to meet the needs of those with lowest salt intakes while at the same time avoiding excessive iodine supply to areas where salt intake is high. In both countries, coordination and collaboration between government agencies and sectors are needed to harmonize food policies to enhance their effectiveness. A multi-sectoral approach backed by a strong political or social interest from government will be most appropriate.

Strengths of the study include: 1) the comparison of salt and iodine intake in two low to middle income countries, both with mandatory salt iodisation programmes but only one with a mandatory salt reduction policy; 2) large nationally representative sample of participants aged 50+ years and; 3) the use of the gold standard method (24-hour urine collection) for measuring salt intake. Limitations include loss of sample size due to incomplete survey or urine collections, and gender disparity with more women than men likely to provide urine samples in both countries. Data collection procedures may have created a selection bias for greater participation by those who were home or had flexible employment requirements.. A lack of dietary intake data limits the ability to identify which sources of food contributed to total salt or iodine intake in both countries. Additionally, this
study excluded pregnant women and children therefore further study is warranted among those iodine-sensitive groups.

7.4 Conclusions

While SA’s salt legislation may influence its population iodine intake, salt iodisation programmes in Ghana require effective regulation. Our findings highlight an urgent need to continually monitor the effectiveness of salt iodisation programmes especially in countries where salt reduction efforts are being undertaken to meet WHO’s global voluntary target of population intake of less than 5g salt/day.

Acknowledgements

The authors thank all study participants for their contributions.

7.5 References


Chapter 8
Towards Population Salt Reduction to Control High Blood Pressure in Ghana: A Policy Direction

This chapter completes the study by discussing actions that were taken, after the initial chapters have provided substantial evidence of sources of dietary salt, level of salt intake, salt use behaviours, hypertension prevalence and the determinants thereof, in Ghana. The chapter details a high-level stakeholder engagement conference that was attended by government agencies, academics, research institutions, non-governmental organizations and international bodies in Ghana, to evaluate the evidence provided and discuss population salt reduction strategies to curb hypertension in the country. This chapter demonstrates roles that government, various agencies, groups and individuals must play to build advocacy and support for salt reduction. The chapter highlights recommendations and action plans that were discussed by stakeholders, and which were to be considered by the Health Ministry of Ghana.

This chapter is the substantive content of the published work:
Abstract

Although population salt reduction is considered a „best buy” in addressing hypertension and cardiovascular disease, Ghana shares a high hypertension burden with a seemingly high salt consumption. This paper discusses best practices in reducing population salt intake and preliminary data on salt and K intake, and the process to develop a road map and identification of actions needed to support the development of a strategic national document towards salt reduction in Ghana. In February 2019, a two-day stakeholder meeting was held with government agencies, researchers, non-governmental organizations, civil society organizations and international partners to deliberate on salt reduction strategies and interventions needed in the face of rising hypertension and other noncommunicable diseases (NCDs) in Ghana. Recommendations were developed from the stakeholder meeting and are being considered for inclusion in the revision of Ghana’s national NCD policy.

8.1 Introduction

Hypertension was highlighted as the leading risk factor for disability and mortality in 2017 Global Burden of Disease Study accounting for 10.4 million deaths and 218 million disability adjusted life lost years [1]. One-third of the global hypertension burden is experienced in LMICs where on average one in three adults are hypertensive [2]. Irrespective of age, the risk of dying from high hypertension in LMICs is more than twice that in high-income countries (HICs). While HICs experienced 7% mortality due to hypertension, LMICs such as those from the African region recorded figures as high as 25% for all persons less than 60 years [3]. The sub-Saharan African region had the greatest burden of hypertension globally as of 2015 [4] and this is projected to increase in the coming decades [5].

Ghana is a country in West Africa with a population of 25,758,108 [6], and that is experiencing rapid economic growth, along with an increase in health expenditure [7, 8]. Over the past two decades, the country has increased its public healthcare spending by 11% [9], however this has not translated into an expected improvement in human resources (as
there is a decline in the number of healthcare personnel) [10] nor enhancement of existing healthcare equipment and facilities [9, 11]. There has been a reported increase in Non-Communicable Disease (NCDs) in Ghana claiming an estimated 86,200 lives each year [12]. The severity of hypertension was demonstrated by Addo et al., where nearly half of people identified with hypertension in Ghana in 2008 had evidence of target end organ damage [13]. In 2014, health facility-based records indicated that hypertension was the leading cause of disability among adults in Ghana [14]. More recent estimates of hypertension prevalence in Ghanaian adults using cohort data of largely 50 years and older, reported a figure of 58.9%, of which 19% aware of their hypertension status. Of those aware of their hypertension status, 67.6% were receiving treatment but only 11.6% of those being treated had controlled BP [15]. Whilst families, communities and economies continue to be impacted by this burden, current health systems are unable to adequately manage the large numbers of persons with hypertension [16]. Preventive strategies are urgently required in Ghana to reduce the hypertension burden. There are two approaches that could be adopted. Reduction in the prevalence of raised BP could be achieved through a shift in the entire distribution of BP to the left, or through a targeted approach to condense the high-blood-pressure tail by implementing intensive clinical interventions to control BP in the hypertensive population [17]. The latter approach depends on well-resourced health services, while the former requires a public health approach. A pooled analysis of 88.6 million participants demonstrated that a change in mean BP of the population is the main driver of the worldwide change in the prevalence of raised BP [17], providing evidence for the effectiveness of a population-wide strategy. Habitual consumption of excess salt is well-known major risk factor for raised BP, and contributes to cardiovascular-related disability and premature deaths globally [18] with one in ten deaths from cardiovascular disease (CVD) being attributed to excessive salt intake [19]. Reducing population salt intake has been identified as a voluntary global target to reducing salt intake by 30% by 2025 and a World Health Organization’s (WHO) “best buy
“strategy to reduce long-term risk of stroke, coronary heart disease and premature mortality from NCDs

[20, 21] Considering this target, international best practice policies, guidelines and interventions have been developed to reduce excessive salt intake at the population level as part of efforts to prevent and control high BP levels. Currently, populations around the world are consuming an average of 9-12 grams of salt a day or around twice the maximum recommendation of the WHO (ie. 5g/day) [22].

It has been estimated that 2.5 million deaths could be prevented each year if global salt consumption was reduced to less than 5g a day [22]. Despite considerable progress towards achieving this goal in many countries [23] low-middle-income countries in Africa have been slow to adopt salt reduction strategies within their public health priorities. Much of the attention in the past has been on infectious diseases [24] though morbidity and mortality from NCDs are projected to overtake infectious diseases by 2030 [25, 26]. With the exception of SA and Mauritius, mandatory legislation to regulate salt content in the food supply has not been adopted on the African continent [23].

In Ghana, most of the population consume processed foods that are high in salt [14] and report a high use of discretionary salt added to foods at the table and in food preparation [27]. Rapid urbanization, population growth and changing lifestyles have resulted in a rapid nutrition transition in the country and that has resulted in an increased intake of processed foods [28]. However, a community-based intervention study has demonstrated that BP could be lowered through behavior change related to salt reduction strategies [29]. As well as salt intake, other lifestyle related risk factors for CVD include lack of physical inactivity, smoking, excessive intake of alcohol and low intake of fruit and vegetables [30].

To address this gap in policy around the need for public health interventions to address the rising prevalence of hypertension and other NCDs in Ghana, an international conference on NCDs was held at the Noguchi Memorial Institute for Medical Research, University of Ghana from the 15th-16th of February, 2019. The conference was organized by the NCDs Support Centre for Africa at the University of Ghana, in collaboration with the University
of Wollongong, Australia, through a grant provided by CDC Foundation with financial support provided by Bloomberg Philanthropies as part of the WHO-SAGE salt sub-study. Additional funding support was received from the Ghana National Petroleum Corporation. Sixty-seven participants attended the conference, including representatives from government agencies, academia, Non-Governmental Organizations (NGOs), Civil Society Organizations (CSOs) and international partners. The conference allowed for plenary and small group discussions to discuss implementation strategies relevant to Ghana, and to plan the way forward for Ghana to adopt a strategy to reduce population level BP through salt reduction policies. Specific objectives of the conference included:

1. To provide a platform for academics, policy makers, CSO/NGOs and state actors to be informed and share experiences/lessons in relation to high BP control using salt reduction strategies.
2. To support participants to understand and make use of the evidence on the best practice interventions to reduce excessive salt intake in foods.
3. To provide a road map and identify necessary actions to support the development of a strategic national document towards salt reduction in Ghana.
4. Identify opportunities for collaboration, capacity building and advocacy to ensure the development of a legislative instrument on salt reduction in foods.

8.2 Meeting Outcomes

Professor Michael Wilson, Director of the NCD Support Centre for Africa, opened the conference and expressed his appreciation and gratitude for such a gathering of people with an intense interest for NCDs in Ghana. Professor Karen Charlton, University of Wollongong, provided a global overview of progress on salt reduction. While highlighting the global NCD targets, she reminded participants of governments” commitment and responsibility to salt reduction and ultimately hypertension [22]. Professor Charlton explained that food reformulation strategies, either through mandatory or voluntary salt targets have been successful in reducing population salt intakes in the United Kingdom and Australia [31].
Multifaceted approaches that include industry salt reduction in foods, food labelling, and consumer education have been successful in various countries. While stressing the feasibility of WHO’s less than 5g salt per day recommendation, she highlighted the need to also monitor population iodine levels in countries with universal salt iodization [32], particularly for children and lactating mothers who are vulnerable to iodine deficiency disorders [33]. Population salt reduction has implication for iodine consumption, as salt is used as the vehicle for iodine fortification. If salt is adequately iodized, a reduction of salt to the recommended level should still provide enough iodine [34]. She demonstrated how WHO’s ‘SHAKE the salt’ package would assist WHO member states with the development, implementation and monitoring of salt reduction strategies to enable them to achieve a reduction in population salt intake [35].

8.3 Local Situation

Dr Dennis Laryea, the NCDs program manager of the Ghana Health Service (GHS) identified a need for more research, to generate local evidence on NCDs to inform policy. He stressed importance of addressing high salt consumption since hypertension is one of the top five NCDs, with regards costs to the Ghana National Health Insurance Scheme. The composition of salt in traditional Ghanaian foods, such as salted fish, is not well documented. The conference was timely in that the NCD unit of the Ghana Health Service was in the process of revising its national policy on NCDs and developing strategic plans for its implementation and thus, relevant insights from the conference will inform its development.

Dr Sandra Boatema, a postdoctoral researcher, provided new (unpublished) data on food sources that contributed the most salt to the Ghanaian diet. These included bread, bouillon cubes, salted fish or meat, instant noodles and pizza with rural populations and communities living in the northern region of Ghana consuming more salty foods than those in urban areas, or those in other regions of the country [14]. The emergence of energy dense, nutrient poor, processed convenience foods such as salty snacks, ready-made baked, desserts and sweetened products has dramatically changed the Ghanaian food environment
While more than a third (36%) of participants during the 2014 Ghana Demographic and Health Survey reported having consumed salted dried fish on a daily basis [14] the Ghana National Iodine Survey Report 2015 reported frequent and widespread use of bouillon cubes with nearly half (48.8%) of the participants reporting consumption of more than 5 times a week [37]. The importance of salt in the Ghanaian cuisine was highlighted by conference delegates as a challenge to changing consumer preferences and food preparation behavior.

Despite the large body of evidence that supports the association between high salt intake and hypertension, very little attention has been given in Ghana in terms of salt reduction policies. Further, only limited small-scale community studies on salt reduction strategies have been conducted [29]. WHO-SAGE biostatistician, Dr Nadia Minicuci, presented data that indicated that much of the NCD burden is preventable or modifiable but stressed that ongoing surveillance is needed to inform policy and to make changes to health systems.

8.4 Interventions to Date

Professor Ama de-Graft Aikins, a social psychologist reported that most of the interventions to address NCDs in Ghana have focused on strengthening three of the six health system building blocks, namely: information systems; health workforce; and service delivery [38]. She recommended the scaling up of interventions that work, making use of cost-effective interventions, addressing NCDs as a developmental issue and empowering communities to be more aware of the risk factors for NCD development. While identifying NCDs interventions, Dr Leonard Baatiema, a postdoctoral researcher, drew the attention to the fact that, despite the increasing burden of NCDs in Ghana, there has not been any systematic effort to profile existing initiatives and interventions in the country to either prevent or control NCDs. Interventions to date that have targeted hypertension, diabetes, stroke and cancer prevention and control have been concentrated in urban cities, mostly Accra and Kumasi [39-43].
8.5 New Data on Salt Intake in Ghana

The paucity of salt intake data in Ghana has been a setback to the initiation of population level salt reduction strategies, as evidence is required to drive political commitment and the public health agenda [32]. Professor Richard Biritwum, the principal investigator of WHO-SAGE, Ghana, provided an overview of the six-country cohort study, with special reference to WHO-SAGE (Ghana) Wave 3 that has incorporated a nested salt sub-study [44]. This sub study is the first attempt to measure national population salt consumption and assess its association with hypertension and co-morbidities in Ghana.

Professor Charlton provided preliminary urinary salt results from WHO-SAGE (Ghana) Wave 3 for one region (Ashanti) out of ten sampled regions. With a mean salt consumption of 8.54±5.23g/day for men and 10.33±7.91g/day for women (n = 277), the younger participants, 18-49yrs (n = 56) consumed more salt (10.91±7.37 g/day) than older adults aged 50+ yrs (n = 221) (9.43±7.00 g/day). It was also noted that, while 73.2% and 79.9% of men and women, respectively, had intakes above the WHO’s < 5g/day salt recommendation, 65.8% and 67% fell short of WHO’s K recommendations of 90mmol/day [45].

Though preliminary, this data obtained from one of the most populated regions of Ghana suggests that salt intake is excessively high in both men and women, and among both young and old. Comparatively, salt intakes seem to be higher in Ghana compared to SA [46] while K intake appears relatively higher in Ghana. In agreement with Professor Charlton’s finding, Elias Menyanu, a PhD candidate, presented data on salt use behavior from WHO-SAGE Ghana Wave 2 data. Compared to South Africans, Ghanaians added more salt to food during cooking, but had much lower levels of obesity and smaller waist circumference measures. As would be expected from major differences in obesity, the South African sample had a higher age-standardised prevalence of hypertension than Ghana [47]. Differences in determinants of awareness, treatment and control of hypertension were also evident between the countries, at least for women. Such differences would need to be considered in policy development. It is clear that salt reduction strategies in Ghana would
need to focus both on salt reduction in the food supply, as well as efforts to raise consumer awareness on discretionary salt use in cooking and added to foods at the table [27].

8.6 Discussion

Throughout the conference and in break-out sessions, participants highlighted the essential role of the Food and Drugs Authority of Ghana (FDA) in the monitoring and surveillance of the food supply, in relation to NCD risk. It was acknowledged that the standards of the FDA do not include how much Na is permissible in various food products. Additionally, Ghana does not have food labelling standards nor does it have adequate laboratory facilities to analyze the Na content of foodstuffs. Representatives from the FDA explained the difficulties and constraints experienced by the directorate from food industry if such regulations were to be adopted and enforced.

Another issue that arose from the lively discussion was the fact that the structure of the basic school level curriculum did not sufficiently inform children with life skills about healthy eating habits, including salt consumption. It was agreed that the Ministry of Health (MOH), in collaboration with the Ministry of Education, should make it mandatory to reduce salt in foods served in schools (particularly schools where the government is implementing the National School Feeding Programme) [48] as well as in other environments, such as workplaces and healthcare institutions.

Despite the existence of a national NCD policy in Ghana [12], a need was identified for more advocacy for NCD prevention, as well as for participants with expert knowledge on NCDs to make themselves available for media communication. There was also a call for stakeholders and researchers to better utilize social media opportunities to ensure dissemination of information on NCDs.

Break out group discussions addressed the following issues, according to the ‘SHAKE the salt’ framework: (1) institutional nutrition standards (2) industry salt reduction targets (3) front of pack labels for packaged food (4) reduction of salt in foods prepared outside the home and (5) behavior change communication to reduce salt use.
8.6.1 Institutional standards
The main issues raised included the implementation of the policy on NCDs which will ensure the targeting of foods containing hidden salts (such as processed and restaurant foods) through legislation and education. Participants discussed a need for the MOH to liaise with other ministries and agencies such as the Ministry of Food and Agriculture [MOFA] and Ministry of Tourism, as well as key institutions to provide a consistent message around salt reduction. The Ghana National Communication Authority (NCA) was identified as a relevant stakeholder in this regard according to its mandate to advocate for consumer education and protection rights. Stricter control of food advertising of unhealthy foods was identified as a priority.

8.6.2 Industry salt reduction targets
There was discussion regarding a need for updated analytical data on food composition in Ghana. Dietary surveys are required to identify foods that are major contributors to total salt intake. Voluntary targets for the food industry regarding maximum salt targets permitted in processed foods were identified as a crucial and the roles of NCA, FDA, NGOs and CSOs as partners in this process was emphasized.

8.6.3 Front of pack labelling for packaged food
The FDA representatives reported that nutrition information panels will soon become mandatory for some categories of food products. Food labels are required to be legible and in bright colors to make them easily identifiable. Discussants argued that the FDA should develop guidelines for salt content in food items and identify those products with high salt using consumer signposting warnings, as has occurred in Chile [49]. Similarly, there was support for restaurants and food outlets to display the salt content of their products. The FDA was urged to improve its education and advocacy programs to promote healthy diets, particularly aiming to reach vulnerable and hard-to-reach communities. In addition, regulation of advertising on food products needs attention by the FDA.

8.6.4 Reduction of salt in foods prepared outside the home
All stakeholders were in agreement of a need to develop a multi-sectoral approach to addressing excess salt in foods consumed outside of the home, including consumer sensitization and education on salt use; removal of salt and bouillon cubes from eating
tables; limiting the consumption of salty snacks; education and training of food vendors; and enforcement of food regulations by the FDA.

8.6.5 Behaviour change communication to reduce salt use
The socio-cultural context was identified as being essential in considering the development of health promotion messages on salt reduction. Discussants suggested using sketches and drama productions in communities to demonstrate the feasibility and benefits of a low salt diet. Other strategies that were suggested included the use of persuasive salt reduction messages, the engagement of role models and opinion leaders to act as ambassadors for salt reduction as well as a national educational campaign on salt reduction.

Several recommendations and associated action plans emerged from the meeting, as summarized in Box 1. These resulted from consensus reached by participants in plenary report-back sessions from breakout groups, and represent views that were unanimously shared by participants.
Box 1. Recommendations and action plans for salt reduction in Ghana

1. Participants emphasized the urgent need to raise awareness of the relationship between excess salt intake and the occurrence of hypertension using various media channels. Given limited policy attention on salt reduction in Ghana, participants agreed on the need for public health education campaigns to reduce high intake of salt among Ghanaians.

2. Foods that contribute large amounts of salt to the Ghanaian diet were to be identified alongside a massive consumer education to reduce the intake of such foods or use healthier alternatives.

3. The Ghana government and the FDA were to negotiate with food industries and food vendors to voluntary reduce salt content in their products.

4. The FDA was to initiate processes that will ensure that most food products have labels.

5. Participants expressed the requirement to explore alternate funding sources to support the implementation of salt reduction interventions. Domestic funding sources from the state, private individuals and organizations should be explored to support hypertension prevention/control interventions.

6. Participants emphasized the need for the provision of adequate resources/facilities for community hypertension screening and information programmes.

7. The GHS and MOH as well as corporate bodies were urged to facilitate the establishment of modern laboratories with the capacity to analyze the Na content and other nutrients in food.

8. Adequate and accurate salt consumption monitoring and surveillance data are required through national research studies. Periodic capture of data at both community and population levels must be prioritized. A current national nutrition survey is needed to support salt intake data to enhance policy formulation.

9. A multisectoral approach was identified as essential in addressing discretionary salt use. Key stakeholders to be included are MOH, GHS, MOFA, etc.
8.7 Conclusion

The importance of using multi-sectoral engagement to promote NCDs has been recognized in the Global Action Plan for the Prevention and Control of NCDs. The outcomes of a high-level stakeholder meeting held in Ghana has demonstrated the feasibility of such an approach in population level salt reduction intake in the country, with nine action items identified for inclusion in Ghana’s national NCD policy.

8.8 References


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Chapter 9
Conclusions and Recommendations

9.1 Overview of core findings

Hypertension is a major burden of disease in many LMICs, including Ghana, a country on the West coast of Africa [1, 2]. The increasing prevalence of hypertension is largely attributed to adoption of unhealthy dietary behaviours resulting from the widespread availability of energy dense nutrient poor (EDNP) foods that are typically high in salt associated with the nutrition transition that accompanies urbanization [3].

The theoretical framework for the thesis was based on the World Health Organization (WHO)’s “SHAKE the Salt Habit” (SHAKE) resource which guides countries that are beginning to address salt reduction strategies. SHAKE recommends firstly identifying quantities and dietary sources of salt intake in the population of interest, as well as determining salt use behaviours and consumer awareness of the adverse health effects of excessive salt intakes. SHAKE also strongly urges intersectoral engagement with key stakeholders to develop policy action to drive governmental efforts towards the reduction of salt intake and to result in a population shift to the left in blood pressure distribution and thereby a lower burden of hypertension [4]. One of the foremost approaches to population salt reduction recommended by SHAKE is the monitoring and evaluation of diets that contribute the most salt to food. Data provided in this thesis is the first step in that process and provides a baseline measure from which further monitoring can be compared.

The body of work in the thesis began with a substantial critical review of existing evidence to identify modifiable determinants of hypertension with a focus on dietary sources of salt in LMICs (Chapter 1). Identified dietary risk factors for hypertension included both a high salt and low potassium intake. The review also considered available salt reduction
strategies and the involvement of food manufacturers in setting of voluntary targets and/or maximum limits of salt in a variety of foods. Additionally, the review identified the key roles played by governments, institutions and private organizations in population salt reduction efforts.

A primary aim of this thesis was to obtain a reliable estimate of current population salt consumption levels, and their relation to blood pressure, in Ghana, for the development of a road map for advocacy, support and policy formulation towards salt reduction. In order to achieve this, the thesis comprised five original studies, which culminated in a high-level stakeholder meeting to obtain consensus on strategies required to address the high prevalence of hypertension and other NCDs in the country.

By leveraging data collected in various waves (1-3) of the large WHO-SAGE prospective study, this novel study adds new knowledge about trends in BP, hypertension prevalence, awareness, treatment, control. In addition to the main survey data, much of this thesis relates to findings of a nested sub-study in which 24hr urinary sodium and potassium collections were obtained to provide much needed information on the salt intake of the Ghanaian population (Chapter 4). This is the first such national data and provides essential evidence to drive policy, planning and further research on salt reduction. The doctoral candidate was involved in all aspects of the data collection and execution of the salt sub-study and worked closely with WHO-SAGE Ghana Primary Investigator, Professor Richard Biritwum to this effect.

Comparison of data from Ghana with that of the WHO-SAGE South African sample (Waves 2 and 3) has provided an opportunity to learn from a country that has adopted a mandatory salt reduction policy that limits maximum salt levels permitted in a wide range of processed foods. WHO-SAGE South Africa Wave 2 was completed immediately prior to implementation of the policy that came into effect in June 2016, whereas Wave 3 was
conducted in the interim period between Phase I and the more stringent Phase II (implemented in June 2019) stages of South Africa’s salt reduction policy.

The gold standard method to assess population salt intake, namely 24hr urinary sodium excretion, was used in both Ghana and South African salt sub-studies (Chapter 4). This method provides an overall quantitative estimation of daily salt intake but does not provide information on dietary sources of salt, and what proportion of salt comes from discretionary (i.e. salt added to food at the table or in cooking) versus non-discretionary (salt inherent in foods, and added to foods during commercial processing) sources. It was not logistically feasible to include a detailed dietary assessment in the WHO-SAGE surveys, however the research team did include validated questions on discretionary salt use behaviours in the main surveys included in both Waves 2 and 3. This allowed comparison between the salt use South African samples as reported in Chapter 3. Interestingly, South Africans were almost five times more likely than Ghanaians to add salt to food at the table but less likely to add salt to food during cooking. To date, little attention, if any, has been given to mass media health education efforts to encourage salt behaviour change in Ghana. These findings support a need for efforts in Ghana to raise consumer awareness on discretionary salt use and provide insight into how to tailor health education and health promotion campaigns on salt use in both countries.

Due to a lack of detailed dietary intake data, a systematic literature review was undertaken to identify major sources of salt intake in LMICs (Chapter 3). Processed foods including breads, meat and meat products, bakery products, instant noodles, salted preserved foods, milk and dairy products, as well as bouillon cubes, were identified as sources of high salt intake in LMICs. The review also identified that drinking water, particularly in drought affected areas, could be a potentially significant source of salt intake. Findings from the review can be used by countries beginning to consider which foods to target for reformulation to lower their salt content.
In order to identify changes in blood pressure that occur with age participants aged 50+y that were present in the WHO-SAGE Ghana Wave 1 (2007/8) cohort and were again followed up in the Wave 3 survey conducted twelve years later in 2019, comprised an analysis to determine the trajectory of BP and its determinants (Chapter 6). Somewhat surprisingly, in these individuals, a fall in diastolic BP was observed but no change in systolic BP which resulted in a consequent increase pulse pressure. Increasing pulse pressure may indicate a higher risk for internal organ damage, myocardial infarctions and cardiovascular events [5, 6]. A decrease in DBP was associated with increasing age, living in rural settings and having health insurance. Though no differences existed over time between the proportion of hypertensives who were receiving antihypertensive treatment, nor the proportion who had their hypertension controlled, the awareness of having hypertension (i.e. diagnosis) increased significantly between the two time periods. Residing in rural areas, having a higher BMI and having voluntary health insurance were associated with increased hypertension awareness. This suggests that health services have become better at diagnosing hypertension, but that hypertension remains poorly managed, once diagnosed. The findings from this study confirm a need to implement non-pharmacological population-based strategies to reduce blood pressure.

To build advocacy and support for salt reduction intervention in Ghana, a population estimate of salt and potassium (K) intake, and their relationship with BP was investigated (Chapter 5). A high salt intake coupled with a low K intake, a relatively higher Na: K and a steeper slope between the high Na: K ratio and age for SBP and DBP in Ghana, indicated both a need for salt reduction strategies in the country but also dietary interventions to increase K intake, commonly found in fruit and vegetables, dairy and animal flesh products. The chapter also highlighted the tendency for populations to underestimate their salt intake and further emphasized the need for periodic evaluation of the food environment using
objective 24hr urinary collections. National dietary surveys are important to elucidate food sources of salt but these should also be accompanied by an updated Ghanaian food composition database that will allow determination of salt from dietary reports.

Due to universal salt iodization (USI) being implemented in Ghana, as in many other countries, to prevent iodine deficiency, the WHO recommends that any assessment of salt intake should be accompanied with determination of adequacy of iodine intakes since both metrics can be determined from urinary outputs. For the first time in Ghana, urinary iodine excretion was compared with salt intake. A novel comparison of iodine-salt intake associations was undertaken between Ghana and South Africa (Chapter 6) because both countries have adopted USI but only South Africa has implemented salt reduction. Since table salt is required by law in both countries to be iodized, it is possible that efforts to lower salt intake may inadvertently lower iodine intake too. Data from participants included in the salt sub-study in both countries for WHO-SAGE Wave 3 identified an overall adequate intake of iodine in Ghana and South Africa, but that urinary iodine excretion differed significantly across salt intake categories in both countries but in opposite directions. In Ghana, a moderate, inverse correlation was observed, compared to a moderate, positive association in SA. Participants with salt intakes <5g/day in South Africa did not meet WHO’s recommended iodine intake of 150µg iodine per day, but this was not the case in Ghana. This study suggests that monitoring and surveillance of iodine status is recommended in countries that have introduced salt reduction strategies (such as South Africa) in order to prevent re-emergence of iodine deficiency. This important finding highlights a need for LMICs to consider salt iodization programmes alongside salt reduction strategies to ensure optimal levels of both iodine intake and reduced salt consumption can be achieved.

The final part of this thesis comprises a high-level stakeholder engagement conference that was held in Ghana in February 2019 to share the findings of the body of work, and to build support and advocacy for salt reduction strategies to reduce hypertension in the country
(Chapter 8). The two-day conference concluded with a 9-point recommendation that is currently being considered for inclusion in the revision of Ghana’s national NCD policy. The outcomes of the conference have been published in an open access international, peer reviewed journal and are available for widespread access by government officials, academics and community-based organizations alike. Bringing together a wide range of important stakeholders has allowed an immediate translation of the research findings into a tool for advocacy for policy change.

Overall, the findings of these study support the hypothesis that salt consumption and hypertension are both high in Ghana. While no direct association was found between salt intake and BP, a higher Na: K ratio was associated with increasing BP with age. This suggests that salt reduction strategies need to be pursued but alongside dietary interventions to increase dietary potassium intake. Such efforts will require collaboration between directorates for NCD Prevention and Nutrition.

9.2 Strengths and Limitations

Methodological strengths and limitation of the study have been briefly outlined below. Specific strengths and limitations for each study have been comprehensively described in each thesis chapter.

The WHO-SAGE study selects a national sample of predominantly older participants, as such findings can be generalized over a large proportion of the population. This cohort of the population form a large number of the vulnerable group in society, as such, this study provides unique and valuable information about this cohort for policy formulation and planning purposes.

The WHO-SAGE study makes use of internationally certified instruments and protocols for data collection. Field workers are extensively trained by WHO experts prior to the commencement of the data collection.
The longitudinal nature of the study offered a rare opportunity to understand the trajectory of BP and its determinants in Ghana. The study was also the maiden attempt to measure population salt, iodine intake, and salt use behaviours in Ghana. The study provided population hypertension prevalence, awareness, treatment and control estimates. The nested sub study utilized the gold standard of 24hr urine collection with volume and creatinine as a marker of urine completeness. Comparison of constructs between Ghana and SA offered a unique learning opportunity and data for planning and further research in LMICs.

The limitations of this thesis include the design of the WHO-SAGE study. The sampling strategy of the study meant that younger people (18-49) were under-represented, thus limiting the ability to generalize findings to the entire adult population. Nevertheless, hypertension is a disease that mostly affects middle-aged and older adults therefore the importance of the findings should not be minimized. Given the complex nature of population-based studies such as WHO-SAGE conducted in LMICs that often have poor infrastructure such as roads, data management issues can be expected and did indeed occur in some cases where missing data was a challenge. Regardless, the overall large sample size still allowed meaningful and statistically relevant analyses to be conducted. Another limitation is the lack of a comprehensive dietary assessment in the WHO-SAGE surveys which limits interpretation about food sources of population salt and potassium intake.

9.3 Future directions

While this thesis makes a substantial and novel contribution to the literature, it also emphasizes the need for more research to strengthen the evidence base and break new grounds.

Based on the findings, the following recommendations from the analysis from Ghana and South Africa are highlighted for wider application to other LMICs:
1. Identification of food products that contribute most salt in respective LMICs is required;
2. Governments in LMICs should engage food manufacturers to discuss the upper limits of salt used in processed foods. Food manufacturers should be encouraged to voluntarily reduce salt in their food products in the absence of mandatory salt reduction legislation;
3. Government in collaboration with NGOs and CSOs should intensify public health education on consumption of excess salt, with particular reference to processed foods;
4. Mass consumer health education is required to sensitize the public on mechanisms to reduce or make healthier alternative choices to high salt foods, particularly for breads, processed meat products, bakery products, instant noodles, salted preserved foods and bouillon cubes; and
5. Public health campaigns on the implications of excess salt intake, should take a settings-based approach, such as health places, schools and health centers.

**Recommendations for Ghana and/or South Africa specifically**

1. Interventions are needed to reduce population salt and to increase K intake in Ghana. It is imperative to identify and increase the intake in order to change dietary Na: K ratios.
2. Current or updated food frequency tables are required in Ghana for better monitoring and evaluation of dietary intakes;
3. There is a need to intensity health promotion programmes that will increase knowledge and instill positive attitudes and behaviours related to lower salt use in both Ghana and South Africa;
4. There is a need to increase BP screening services within communities in Ghana. Community centers and marketplaces in Ghana could be additional avenues for BP screening services to obtain hard-to-reach persons;
5. There is the need to regularly monitor iodine intake in both Ghana and South Africa to prevent re-emergence of iodine deficiency in the face of salt reduction strategies;
6. A further study is strongly recommended to ascertain the effectiveness of the more stringent (Phase II) salt legislation in South Africa.

9.4 Summary

In conclusion, this thesis has provided and addressed gaps in data on population salt intake and hypertension in Ghana, and made useful comparisons with South Africa. A total of five studies and one conference report addressed the overarching research question and added new knowledge to the existing body of scientific evidence. The thesis contributes to the field of nutrition, ageing, dietetic and public health with each study uniquely designed to address a specific public health issue. Translational aspects of the research have been addressed through a stakeholder consultation meeting held in 2019 that resulted in a road map of activities that are required for policy formulation on population salt reduction.

9.5 References


4. SHAKE the salt habit. https://apps.who.int/iris/bitstream/handle/10665/250135/97892415-11346eng.pdf;jsessionid=0E71054ADB60FCAD1E5BA6906AA91D59?sequence=1 Accessed 25/08/19


### Appendices

#### Appendix A - Risk of bias assessment

<table>
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<th>Included Studies</th>
<th>Were the aims/objectives of the study clear?</th>
<th>Was the design appropriate for the aim(s) stated?</th>
<th>Was the sample size justified?</th>
<th>Was the target population clearly defined?</th>
<th>Was the sample taken from an appropriate population base?</th>
<th>Was the selection process able to select a representative sample?</th>
<th>Were measures undertaken to address and categorize non-respondents?</th>
<th>Were risk factors and outcome measured appropriate to the aims of the study?</th>
<th>Is it clear what was used to determine statistical or precision estimates?</th>
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Appendix B – Instruments for data collection and consent forms
https://www.who.int/healthinfo/sage/cohorts/en/index2.html
www.who.int › survey › SAGESurveyManualFinal
Appendix C - WHO Research Ethics Review Committee [RPC149]

Research Ethics Review Committee (WHO ERC)

WHO ERC
Review Summary - Continuing Review

Protocol ID: RPC149
Protocol Title: WHO Multi-Country Study on Global Ageing and Adult Health (SAGE)
WHO Responsible Staff Member: CHATTERJI, S.
Responsible Unit: IER/MHI

The complete documentation for the continuing review of this project was submitted to the Secretariat on 06/08/2013. This was last approved by ERC on 07/04/2012. The annual report of this project has been reviewed by the secretariat and the Chairperson. The outcome of the review is as follows:

1. There have been no changes to the protocol or the informed consent form. The same protocol will be used for Waves 2 and 3 of the study.
2. A technical meeting was held at WHO in December 2012 with SAGE country PI's and survey team members to discuss and plan Wave 2 in 2013. Wave 1 results and technical debriefing was conducted. Briefing for Wave 2 was done – including parameters for continuation with the survey and future contracts with WHO.
3. The Unit is satisfied with the progress of the project.
4. No ethical issues for concern have been reported during the past approval period.

Based on these considerations, the project is approved for one more year. The WHO TO is requested to submit the proposal for a re-review after one year.

Chairperson.......................... Date......................

Name: Melba Gomez/Alejandro Costa/Emille Allred

NOTE
Any changes to the proposal or to the attachments (informed consent/ questionnaires etc.) should be approved by ERC before being implemented.
The approval for this proposal is valid for a period of one year only. Please resubmit this proposal for a Continuing Review at least 2 months before the next re-approval period.

ERC Secretariat Page 1 of 1 Date 29/06/2013
UNIVERSITY OF GHANA MEDICAL SCHOOL
COLLEGE OF HEALTH SCIENCES
ACADEMIC AFFAIRS OFFICE

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My Ref. No: MS-AA/C.2/Vol.18A
Year Ref. No.

Professor Richard Britwum
Dept. of Community Health
UGMS

P O Box 4236
Accra
Ghana
4th March, 2014

RENEWAL OF ETHICAL CLEARANCE


The Ethical and Protocol Review Committee of the University of Ghana Medical School on 3rd March, 2014 unanimously approved your research proposal.

TITLE OF PROTOCOL: "WHO Study on Ageing and Adult Health (SAGE)" WAVE 2

PRINCIPAL INVESTIGATOR: Professor Richard Britwum

This approval requires that you submit six-monthly review reports of the protocol to the Committee and a final full review to the Ethical and Protocol Review Committee at the completion of the study. The Committee may observe, or cause to be observed, procedures and records of the study during and after implementation.

Please note that any significant modification of this project must be submitted to the Committee for review and approval before its implementation.

You are required to report all serious adverse events related to this study to the Ethical and Protocol Review Committee within seven (7) days verbally and fourteen (14) days in writing.

As part of the review process, it is the Committee’s duty to review the ethical aspects of any manuscript that may be produced from this study. You will therefore be required to furnish the Committee with any manuscript for publication.

This ethical clearance is valid till 31st March, 2015.

Further renewal of approval will be given upon presentation of an annual report of work done.

Please always quote the protocol identification number in all future correspondence in relation to this protocol.

Signed:-------------------------
PROFESSOR JENNIFER WELBECK
(CHAIRPERSON, ETHICAL AND PROTOCOL REVIEW COMMITTEE)
## Appendix E - Supplementary Materials

### Supplementary Table 3.1 Included articles and their regions of origin

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<th>Study Emphasis</th>
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Supplementary Table 5.1: Na, K, Cl and Cr of original and repeat data in the same participants in Alajo EA

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<th>Women (n = 566)</th>
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<td>1.9 (1.5)</td>
<td>2.1 (1.7)</td>
<td></td>
</tr>
<tr>
<td>Achieving Na:K ratio (≤1.0), n (%)</td>
<td>n = 825</td>
<td>n = 267</td>
<td>n = 558</td>
<td>0.20</td>
</tr>
<tr>
<td></td>
<td>59 (6.3)</td>
<td>21 (7.9)</td>
<td>31 (5.6)</td>
<td></td>
</tr>
<tr>
<td>Cr, mmol/24h</td>
<td>n = 835</td>
<td>n = 269</td>
<td>n = 566</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>3.4 (2.4)</td>
<td>3.6 (2.6)</td>
<td>3.3 (2.3)</td>
<td></td>
</tr>
<tr>
<td>24hr Iodine, µg/l</td>
<td>n = 799</td>
<td>n = 255</td>
<td>n = 544</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>140.8 (140.1)</td>
<td>154.6 (152.3)</td>
<td>137.8 (137.8)</td>
<td></td>
</tr>
</tbody>
</table>

Data are presented as median (IQR) unless otherwise stated; Mann-Whitney Test used to compare medians, Pearson Chi-Square test and Fisher’s Exact Test used to compare proportional data.
**Supplementary Table 5.3: Urine results for electrolytes, creatinine and iodine by age (urine data considered valid if volume > 300ml), WHO-SAGE Ghana Wave 3**

<table>
<thead>
<tr>
<th></th>
<th>≥50 years (n = 661)</th>
<th>18-49yrs (n = 174)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>24hour Urine Analysis</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sodium, mmol/24hr</td>
<td>n = 656</td>
<td>n = 173</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td></td>
<td>136.4 (120.3)</td>
<td>164.3 (138.2)</td>
<td></td>
</tr>
<tr>
<td>Salt excretion, g/day</td>
<td>n = 656</td>
<td>n = 173</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td></td>
<td>8.1 (7.1)</td>
<td>9.7 (8.2)</td>
<td></td>
</tr>
<tr>
<td>Achieving salt target (&lt;5g/day), n (%)</td>
<td>n = 654</td>
<td>n = 173</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td></td>
<td>159 (24.3)</td>
<td>21 (12.1)</td>
<td></td>
</tr>
<tr>
<td>Potassium (K), mmol/24hr</td>
<td>n = 661</td>
<td>n = 174</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td></td>
<td>61.7 (66.8)</td>
<td>80.4 (93.3)</td>
<td></td>
</tr>
<tr>
<td>Achieving K target (≥90 mmol/day), n (%)</td>
<td>n = 661</td>
<td>n = 174</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td></td>
<td>212 (32.1)</td>
<td>79 (45.4)</td>
<td></td>
</tr>
<tr>
<td>Sodium-to-potassium ratio</td>
<td>n = 656</td>
<td>n = 173</td>
<td>0.33</td>
</tr>
<tr>
<td></td>
<td>2.1 (1.6)</td>
<td>2.1 (1.8)</td>
<td></td>
</tr>
<tr>
<td>Achieving Na:K ratio (≤1.0), n (%)</td>
<td>n = 653</td>
<td>n = 172</td>
<td>0.45</td>
</tr>
<tr>
<td></td>
<td>39 (6.0)</td>
<td>13 (7.6)</td>
<td></td>
</tr>
<tr>
<td>Cr, mmol/24h</td>
<td>n = 661</td>
<td>n = 174</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td></td>
<td>3.4 (2.2)</td>
<td>4.1 (2.5)</td>
<td></td>
</tr>
<tr>
<td>24hr Iodine, µg/l</td>
<td>n = 629</td>
<td>n = 170</td>
<td>0.63</td>
</tr>
<tr>
<td></td>
<td>144.2 (141.6)</td>
<td>146.5 (137.5)</td>
<td></td>
</tr>
</tbody>
</table>

Data are presented as median (IQR) unless otherwise stated; Mann-Whitney Test used to compare medians, Pearson Chi-Square test and Fisher’s Exact Test used to compare proportional data.
Supplementary Table 5.4: Salt knowledge, attitudes and behaviour and fruits and vegetable consumption by age category, sex and location (n = 837), nested sub study; WHO-SAGE Ghana Wave 3.

<table>
<thead>
<tr>
<th></th>
<th>All (n = 837)</th>
<th>Age Category</th>
<th>p value</th>
<th>Sex (837)</th>
<th>p value</th>
<th>Location (837)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>50+ yrs</td>
<td>18-49 yrs</td>
<td>Men</td>
<td>Women</td>
<td>Urban</td>
<td>Rural</td>
</tr>
<tr>
<td>Add salt to food at the table, frequently n (%)</td>
<td>107 (12.8)</td>
<td>n = 664</td>
<td>n = 173</td>
<td>n = 270</td>
<td>n = 568</td>
<td>n = 456</td>
<td>n = 381</td>
</tr>
<tr>
<td></td>
<td></td>
<td>78 (11.7)</td>
<td>28 (27.3)</td>
<td>39 (14.4)</td>
<td>68 (12.0)</td>
<td>46 (10.1)</td>
<td>61 (16.0)</td>
</tr>
<tr>
<td>Add salt to cooking at home, frequently n (%)</td>
<td>671 (80.1)</td>
<td>n = 664</td>
<td>n = 173</td>
<td>n = 270</td>
<td>n = 568</td>
<td>n = 456</td>
<td>n = 381</td>
</tr>
<tr>
<td></td>
<td></td>
<td>520 (78.3)</td>
<td>150 (86.7)</td>
<td>219 (81.1)</td>
<td>452 (79.6)</td>
<td>358 (78.5)</td>
<td>312 (81.9)</td>
</tr>
<tr>
<td>How much salt consumed, just the right amount n (%)</td>
<td>508 (60.9)</td>
<td>n = 662</td>
<td>n = 171</td>
<td>n = 269 178</td>
<td>n = 565</td>
<td>n = 455</td>
<td>n = 378</td>
</tr>
<tr>
<td></td>
<td></td>
<td>387 (58.5)</td>
<td>120 (70.2)</td>
<td>(66.2)</td>
<td>330 (58.4)</td>
<td>265 (58.2)</td>
<td>242 (64.0)</td>
</tr>
<tr>
<td>Can high salt diet cause a serious health problem, yes no (%)</td>
<td>651 (77.8)</td>
<td>n = 643</td>
<td>n = 170</td>
<td>n = 264</td>
<td>n = 549</td>
<td>n = 444</td>
<td>n = 368</td>
</tr>
<tr>
<td></td>
<td></td>
<td>517 (80.5)</td>
<td>134 (78.8)</td>
<td>216 (81.8)</td>
<td>435 (79.2)</td>
<td>362 (81.5)</td>
<td>288 (78.3)</td>
</tr>
<tr>
<td>Do you do anything on regular basis to control salt consumption, no (%)</td>
<td>394 (51.5)</td>
<td>n = 643</td>
<td>n = 169</td>
<td>n = 259</td>
<td>n = 553</td>
<td>n = 445</td>
<td>n = 366</td>
</tr>
<tr>
<td></td>
<td></td>
<td>320 (49.8)</td>
<td>74 (43.8)</td>
<td>136 (52.5)</td>
<td>282 (51.0)</td>
<td>216 (48.5)</td>
<td>201 (54.9)</td>
</tr>
<tr>
<td>Fruits and vegetable intake, did not meet recommendation n (%)</td>
<td>396 (47.2)</td>
<td>n = 644</td>
<td>n = 173</td>
<td>n = 270</td>
<td>n = 568</td>
<td>n = 457</td>
<td>n = 381</td>
</tr>
<tr>
<td></td>
<td></td>
<td>312 (47.0)</td>
<td>83 (48.0)</td>
<td>126 (46.7)</td>
<td>270 (47.5)</td>
<td>209 (45.7)</td>
<td>186 (48.8)</td>
</tr>
</tbody>
</table>

Data was recorded in frequencies. Chi square tests were conducted.
Supplementary Table 6.1: Odds ratio showing the predictors of decrease in hypertension prevalence (WHO-SAGE Ghana Waves 1 and 3), n = 368

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>OR</th>
<th>p-value</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(95% CI)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertension prevalence</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>Ref</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>1.08</td>
<td>0.759</td>
<td>0.66-1.76</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td>0.99</td>
<td>0.422</td>
<td>0.98-1.01</td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>Ref</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural</td>
<td>0.48</td>
<td>&lt; 0.01</td>
<td>0.30-0.77</td>
</tr>
<tr>
<td><strong>Marital Status</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>Ref</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not married</td>
<td>1.80</td>
<td>0.125</td>
<td>0.45-1.10</td>
</tr>
<tr>
<td><strong>Years of education</strong></td>
<td>1.04</td>
<td>0.076</td>
<td>0.99-1.09</td>
</tr>
<tr>
<td><strong>Mothers education</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than secondary/high school completed</td>
<td>Ref</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary/high school and above completed</td>
<td>0.64</td>
<td>0.397</td>
<td>0.23-1.78</td>
</tr>
<tr>
<td>Hypertension prevalence</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Characteristic</td>
<td>OR</td>
<td>p-value</td>
<td>95 CI</td>
</tr>
<tr>
<td></td>
<td>(95% CI)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fathers education</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than secondary/high school completed</td>
<td>Ref</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary/high school and above completed</td>
<td>0.91</td>
<td>0.727</td>
<td>0.55-1.52</td>
</tr>
<tr>
<td>Health Insurance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>Ref</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>1.33</td>
<td>0.138</td>
<td>0.91-1.01</td>
</tr>
<tr>
<td>BMI</td>
<td>0.98</td>
<td>0.135</td>
<td>0.96-1.01</td>
</tr>
<tr>
<td>Ever used alcohol</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>Ref</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>0.97</td>
<td>0.885</td>
<td>0.67-1.40</td>
</tr>
<tr>
<td>Diabetes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>Ref</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>0.57</td>
<td>0.122</td>
<td>0.27-1.16</td>
</tr>
<tr>
<td>Ever used tobacco</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>Ref</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>0.78</td>
<td>0.284</td>
<td>0.49-1.22</td>
</tr>
<tr>
<td>Overall physical activity</td>
<td>1.04</td>
<td>0.821</td>
<td>0.71-1.53</td>
</tr>
</tbody>
</table>

Note: Ref represents reference category used for the comparison. Voluntary refers to contributors to health insurance who were not captured by the insurance scheme as public or civil service workers, while mandatory refers to contributors who were employees within the public, civil and private sectors. Overall physical activity represents all activities including vigorous, moderate, walking/cycling, vigorous fitness and moderate fitness completed in a typical week. Multivariate regression was adjusted age, sex, marital status, years of education, mother’s education, father’s education, health insurance, diabetes and overall physical activity.
Supplementary Table 6.2: Characteristics of Wave 1 participants included in the study (50+y, n = 820) and those excluded (n = 3,904)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Wave 1 included</th>
<th>Wave 1 excluded</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age in years, Median (IQR)</td>
<td>n = 820</td>
<td>n = 3904</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td></td>
<td>59 (13)</td>
<td>64 (17)</td>
<td></td>
</tr>
<tr>
<td>Location: Urban, n(%)</td>
<td>n = 820</td>
<td>n = 3904</td>
<td>0.0196</td>
</tr>
<tr>
<td></td>
<td>364 (44.4)</td>
<td>1561 (40.0)</td>
<td></td>
</tr>
<tr>
<td>Gender: Male, n(%)</td>
<td>n = 820</td>
<td>n = 3904</td>
<td>0.2080</td>
</tr>
<tr>
<td></td>
<td>433 (52.8)</td>
<td>1920 (49.2)</td>
<td></td>
</tr>
<tr>
<td>Education: Schooled, n (%)</td>
<td>n = 817</td>
<td>n = 3476</td>
<td>0.0217</td>
</tr>
<tr>
<td></td>
<td>398 (48.7)</td>
<td>1539 (44.3)</td>
<td></td>
</tr>
<tr>
<td>Marital status: Married/cohabiting, n (%)</td>
<td>n = 817</td>
<td>n = 3880</td>
<td>0.3262</td>
</tr>
<tr>
<td></td>
<td>489 (59.9)</td>
<td>2250 (58.0)</td>
<td></td>
</tr>
<tr>
<td>SR Hypertension, n (%)</td>
<td>n = 820</td>
<td>n = 3469</td>
<td>0.0567</td>
</tr>
<tr>
<td></td>
<td>95 (11.6)</td>
<td>490 (14.1)</td>
<td></td>
</tr>
<tr>
<td>SR Diabetes, n (%)</td>
<td>n = 820</td>
<td>n = 3469</td>
<td>0.0027</td>
</tr>
<tr>
<td></td>
<td>17 (2.1)</td>
<td>150 (4.3)</td>
<td></td>
</tr>
<tr>
<td>SR Depression, n (%)</td>
<td>n = 820</td>
<td>n = 3469</td>
<td>0.9524</td>
</tr>
<tr>
<td></td>
<td>13 (1.6)</td>
<td>54 (1.6)</td>
<td></td>
</tr>
<tr>
<td>SR Health, very good n (%)</td>
<td>n = 820</td>
<td>n = 3481</td>
<td>0.1893</td>
</tr>
<tr>
<td></td>
<td>39 (4.8)</td>
<td>131 (3.8)</td>
<td></td>
</tr>
</tbody>
</table>
Supplementary Table 6.3: Characteristics of Wave 1 participants included in the study (50+y, n = 820) and those followed-up but excluded from analysis (n = 79)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Wave 1 included</th>
<th>Wave 1 followed-up but excluded</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age in years, Median (IQR)</td>
<td>n = 820 59 (13)</td>
<td>n = 79 59 (13)</td>
<td>0.7791</td>
</tr>
<tr>
<td>Location: Urban, n(%)</td>
<td>n = 820 364 (44.4)</td>
<td>n = 79 30 (38.0)</td>
<td>0.2724</td>
</tr>
<tr>
<td>Gender: Male, n(%)</td>
<td>n = 820 433 (52.8)</td>
<td>n = 79 31 (39.2)</td>
<td>0.0210</td>
</tr>
<tr>
<td>Education: Schooled, n (%)</td>
<td>n = 818 398 (48.7)</td>
<td>n = 25 11 (44.0)</td>
<td>0.6422</td>
</tr>
<tr>
<td>Marital status: Married/cohabiting, n (%)</td>
<td>n = 817 489 (59.9)</td>
<td>n = 77 60 (77.9)</td>
<td>0.0018</td>
</tr>
<tr>
<td>SR Hypertension, n (%)</td>
<td>n = 820 95 (11.6)</td>
<td>n = 24 3 (12.5)</td>
<td>0.7520</td>
</tr>
<tr>
<td>SR Diabetes, n (%)</td>
<td>n = 820 17 (2.1)</td>
<td>n = 24 1 (4.2)</td>
<td>0.4082</td>
</tr>
<tr>
<td>SR Depression, n (%)</td>
<td>n = 820 13 (1.6)</td>
<td>n = 24 0 (0.0)</td>
<td>-</td>
</tr>
<tr>
<td>SR Health, very good n (%)</td>
<td>n = 820 39 (4.8)</td>
<td>n = 25 1 (4.0)</td>
<td>1.0000</td>
</tr>
</tbody>
</table>
Supplementary Table 7.1 Demographic profile of SAGE Ghana and South Africa W3 survey respondents and subsample with urine valid data (urine data considered valid if Volume ≥ 300ml & creatinine ≥3mmol).

<table>
<thead>
<tr>
<th></th>
<th>Ghana Main SAGE cohort (n=3053)</th>
<th>Ghana Subsample with CAPI &amp; urine (n=495)</th>
<th>P-value</th>
<th>South Africa Main SAGE cohort (n=1501)</th>
<th>South Africa Subsample with CAPI &amp; urine (n=707)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Years</td>
<td>60 (20)</td>
<td>57 (18)</td>
<td>0.0002</td>
<td>58 (19)</td>
<td>61 (15)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>18-49 years, n (%)</td>
<td>717 (23.5)</td>
<td>133 (26.9)</td>
<td>0.0159</td>
<td>399 (26.6)</td>
<td>112 (15.8)</td>
<td>0.0140</td>
</tr>
<tr>
<td>50 plus years, n (%)</td>
<td>2336 (76.5)</td>
<td>362 (73.1)</td>
<td>0.0001</td>
<td>1102 (73.4)</td>
<td>595 (84.2)</td>
<td>0.2393</td>
</tr>
<tr>
<td><strong>Sex, n (%)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>1183 (38.8)</td>
<td>171 (34.6)</td>
<td>0.074</td>
<td>539 (35.9)</td>
<td>218 (30.8)</td>
<td>0.019</td>
</tr>
<tr>
<td>Women</td>
<td>1870 (61.2)</td>
<td>324 (65.4)</td>
<td></td>
<td>962 (64.1)</td>
<td>489 (69.2)</td>
<td></td>
</tr>
<tr>
<td><strong>Ethnicity, n (%)</strong></td>
<td></td>
<td></td>
<td>&lt;0.002</td>
<td></td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Akan</td>
<td>1544 (50.6)</td>
<td>280 (56.6)</td>
<td></td>
<td>1034 (68.9)</td>
<td>516 (73.0)</td>
<td></td>
</tr>
<tr>
<td>Ewe</td>
<td>216 (7.1)</td>
<td>34 (6.9)</td>
<td></td>
<td>296 (19.7)</td>
<td>157 (22.2)</td>
<td></td>
</tr>
<tr>
<td>Ga-Adangbe</td>
<td>224 (7.3)</td>
<td>29 (5.9)</td>
<td></td>
<td>72 (4.8)</td>
<td>15 (2.1)</td>
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</tr>
<tr>
<td>Gruma</td>
<td>30 (1.0)</td>
<td>3 (0.6)</td>
<td></td>
<td>98 (6.5)</td>
<td>18 (2.6)</td>
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</tr>
<tr>
<td>Grusi</td>
<td>76 (2.5)</td>
<td>7 (1.4)</td>
<td></td>
<td>1 (0.1)</td>
<td>1 (0.1)</td>
<td></td>
</tr>
<tr>
<td>Guan</td>
<td>38 (1.2)</td>
<td>10 (2.0)</td>
<td></td>
<td></td>
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<tr>
<td>Mande-Busanga</td>
<td>63 (2.1)</td>
<td>1 (0.2)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Mole-Dagbon</td>
<td>174 (5.7)</td>
<td>16 (3.2)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Other</td>
<td>612 (20.0)</td>
<td>112 (22.6)</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td><strong>Residence, n (%)</strong></td>
<td></td>
<td></td>
<td>0.001</td>
<td></td>
<td></td>
<td>0.001</td>
</tr>
<tr>
<td>Urban</td>
<td>1301 (42.6)</td>
<td>262 (52.9)</td>
<td></td>
<td>1076 (71.7)</td>
<td>456 (64.5)</td>
<td></td>
</tr>
<tr>
<td>Rural</td>
<td>1752 (57.4)</td>
<td>233 (47.1)</td>
<td></td>
<td>425 (28.3)</td>
<td>251 (35.5)</td>
<td></td>
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<tr>
<td></td>
<td>Ghana</td>
<td>South Africa</td>
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<tr>
<td></td>
<td>Main SAGE cohort</td>
<td>Main SAGE cohort</td>
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<tr>
<td></td>
<td>(n=3053)</td>
<td>(n=1501)</td>
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<tr>
<td></td>
<td>Subsample with</td>
<td>Subsample with</td>
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<tr>
<td></td>
<td>CAPI &amp; urine</td>
<td>CAPI &amp; urine</td>
<td></td>
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<tr>
<td></td>
<td>(n=495)</td>
<td>(n=707)</td>
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<td></td>
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<tr>
<td><strong>P-value</strong></td>
<td>0.324</td>
<td>0.027</td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Marital status, n (%)</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never married</td>
<td>208 (6.8)</td>
<td>484 (32.2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>29 (5.9)</td>
<td>202 (28.6)</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Married/cohabiting</td>
<td>1760 (57.7)</td>
<td>495 (33.0)</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>302 (61.0)</td>
<td>213 (30.1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Separate/divorced</td>
<td>369 (12.1)</td>
<td>132 (8.8)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>48 (9.7)</td>
<td>69 (9.8)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Widowed</td>
<td>715 (23.4)</td>
<td>390 (26.0)</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>116 (23.4)</td>
<td>223 (31.5)</td>
<td></td>
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</tr>
<tr>
<td><strong>Never been to school, n (%)</strong></td>
<td>1119 (36.7)</td>
<td>127 (8.5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>125 (25.2)</td>
<td>79 (11.2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education (Years)</td>
<td>10 (5)</td>
<td>12 (5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10 (4)</td>
<td>10 (5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Body Mass Index (kg/m²)</strong></td>
<td>24.2 (6.8)</td>
<td>29.4 (8.9)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25.7 (6.9)</td>
<td>29.8 (10.3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Waist to height ratio</strong></td>
<td>0.54 (0.11)</td>
<td>0.56 (0.13)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.56 (0.12)</td>
<td>0.59 (0.14)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Never used alcohol, n (%)</strong></td>
<td>1865 (61.3)</td>
<td>1049 (70.3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>283 (57.2)</td>
<td>511 (72.3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Never used tobacco, n (%)</strong></td>
<td>2739 (90.0)</td>
<td>1106 (74.1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>453 (91.5)</td>
<td>528 (74.7)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Systolic BP (mm Hg)</strong></td>
<td>124 (26.5)</td>
<td>130 (23.5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>125.5 (28)</td>
<td>133.5 (29)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Diastolic BP (mm Hg)</strong></td>
<td>76 (17)</td>
<td>83 (19)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>76.5 (17)</td>
<td>83.5 (20.5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Hypertension, n(%)</strong></td>
<td>1132 (37.6)</td>
<td>831 (58.8)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>208 (42.2)</td>
<td>447 (65.2)</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Diabetes, n(%)</strong></td>
<td>157 (5.2)</td>
<td>182 (12.2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>38 (7.7)</td>
<td>119 (16.9)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Frequently add salt to food at table, n(%)</strong></td>
<td>642 (21.1)</td>
<td>264 (17.7)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>58 (11.7)</td>
<td>108 (15.3)</td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td>Ghana</td>
<td>South Africa</td>
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<tr>
<td></td>
<td>Main SAGE cohort (n=3053)</td>
<td>Main SAGE cohort (n=1501)</td>
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<tr>
<td></td>
<td>Subsample with CAPI&amp;urine (n=495)</td>
<td>Subsample with CAPI&amp;urine (n=707)</td>
<td></td>
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<tr>
<td><strong>P-value</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Frequently add salt to food during cooking, n(%)</strong></td>
<td>2527 (83.0)</td>
<td>965 (64.7)</td>
<td>0.189</td>
<td>460 (65.1)</td>
<td>0.860</td>
<td></td>
</tr>
<tr>
<td><strong>Believe they consume too much salt, n(%)</strong></td>
<td>265 (8.8)</td>
<td>156 (10.9)</td>
<td>0.503</td>
<td>48 (9.7)</td>
<td>59 (8.6)</td>
<td>0.104</td>
</tr>
<tr>
<td><strong>Believe a high salt diet is bad for health, n(%)</strong></td>
<td>2247 (75.9)</td>
<td>1121 (82.9)</td>
<td>0.266</td>
<td>378 (78.3)</td>
<td>506 (81.6)</td>
<td>0.480</td>
</tr>
<tr>
<td><strong>Regularly control of salt intake, n(%)</strong></td>
<td>1243 (42.1)</td>
<td>552 (41.1)</td>
<td>0.005</td>
<td>235 (48.9)</td>
<td>255 (42.7)</td>
<td>0.514</td>
</tr>
</tbody>
</table>

Subsample: all respondent with CAPI data and valid urine, sex and age recorded. Some variables may contain missing data. Data are presented as median (IRQ) unless otherwise indicated. Hypertensive by measured BP≥140 and/or 90 mm Hg or previous self-reported treatment in the past two weeks prior to the survey. Ethnicity, marital status, education, alcohol/tobacco use and diabetes prevalence by self-report. Mann-Whitney Test used to compare medians, Pearson Chi-Square test and Fisher’s Exact Test used to compare proportional data.
Appendix F – Dietary Sources of Salt in Low- and Middle-Income Countries: A Systematic Literature Review

Review

Dietary Sources of Salt in Low- and Middle-Income Countries: A Systematic Literature Review

Elias Menyanu 1,2, Joanna Russell 2 and Karen Charlton 1,3,*

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2 School of Health and Society, Faculty of Social Sciences, University of Wollongong, Northfields Avenue, Wollongong, NSW 2522, Australia; jrnosell@uow. edu.au
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Abstract: Rapid urbanization in low- and middle-income countries (LMICs) is transforming dietary patterns from reliance on traditional staples to increased consumption of energy-dense foods high in saturated fats, trans fats, sugars, and salt. A systematic literature review was conducted to determine major food sources of salt in LMICs that could be targeted in strategies to lower population salt intake. Articles were sourced using Medline, Web of Science, Scopus, and grey literature. Inclusion criteria were: reported dietary intake of Na/salt using dietary assessment methods and food composition tables and/or laboratory analysis of salt content of specific foods in populations in countries defined as low or middle-income (LMIC) according to World Bank criteria. Of the 5207 records retrieved, 15 studies conducted in 12 LMICs from diverse geographical regions met the eligibility criteria. The major sources of dietary salt were breads, meat and meat products, bakery products, instant noodles, salted preserved foods, milk and dairy products, and condiments. Identification of foods that contribute to salt intake in LMICs allows for development of multi-faceted approaches to salt reduction that include consumer education, accompanied by product reformulation.

Keywords: dietary salt; sources of salt; salt intake in LMICs; systematic literature review

1. Introduction

Cardiovascular diseases (CVDs) are the leading cause of death worldwide [1], with hypertension accounting for more than 50% of premature deaths [2]. Globally, the prevalence of hypertension has been rising from a figure of 25% reported in 2000 [3] to 40% reported by others in 2008 [4]. Hypertension is the leading single risk factor contributing to overall Global Burden of Disease [2] through its association with cardiovascular disease. Low- and middle-income countries (LMICs) already share the highest prevalence of hypertension [5], with predictions that three quarters of the world’s hypertensive population will be found in these countries within the next 10 years [3]. This may be in part due to the larger population sizes in LMICs compared to high-income countries, but also because of the inability of their health care systems to cope with the management of chronic diseases. This results in large numbers of people with undiagnosed, untreated, and uncontrolled hypertension [6].

Low- and middle-income countries are currently facing an unprecedented hypertension burden [6]. The past four decades have seen a shift in the highest blood pressure (BP) levels from high-income countries to LMICs, particularly in some South Asian and sub-Saharan African countries [7] where more than a third of adults report being hypertensive [6]. Additionally, there is low awareness, treatment, and control measures for hypertension in LMICs [8], rendering current practices to reduce hypertension ineffective [9,10]. Ultimately, the worsening situation of hypertension together with...
increased prevalence of cancers, diabetes, and chronic respiratory diseases have culminated in nearly 80% of all deaths from non-communicable diseases (NCDs) occurring in LMICs [11].

The nutrition transition in many LMICs is occurring due to the rapid urbanization which has led to widespread availability of energy-dense foods that are high in saturated fats, trans fats, sugars, and salt. This has resulted in a shift in dietary patterns from a reliance on traditional staples such as maize and sorghum to more processed foods [12].

At the same time, food insecurity remains a challenge in LMICs [13]. Preserving food using traditional methods (e.g., salting) is important in ensuring food availability and addressing hunger in many communities [14,15]. Further, limited water supplies [16] have exposed populations to unhealthy water sources which often contain toxins or unacceptable levels of nutrients [17,18]. A mean Na concentration of about 700 mg/L (with extremes exceeding 1500 mg/L) was found in drinking water in coastal areas of Bangladesh [19] contributing to the overall daily Na consumption of people living along the coast. With this, the WHO’s recommended daily limit of 5 g salt [20] can easily be exceeded by just drinking 2-3 L of water in some countries.

There is compelling evidence from epidemiological, clinical, and experimental studies showing a positive and direct relationship between salt consumption and BP. It is widely accepted that high intakes of salt in food (beyond the WHO’s recommended level of 5 g salt or 2 g Na/day) and in water (>0.2 g Na/L) are major risk factors for hypertension [20,21], heart disease, and stroke [22]. Sodium (Na) is an important nutrient required by the body to ensure acid-base balance, maintenance of plasma volume, and transmission of nerve impulses [23]; however, when in excess, has been implicated in the development of kidney disease, gastric cancer, and hypertension [24,25]. Lower levels of Na (<3 g/d) have also been identified to be associated with higher risk of death and cardiovascular events [26]. Several prospective cohort studies have indicated a U-shaped relationship between salt consumption and cardiovascular disease or mortality, with increased risk at both high- and low-intake extremes [27-30]. In comparison with a moderate consumption of salt, observational data demonstrate that very high intakes (>6 g Na/day, representing only 10% of the population studied) are associated with an excessive risk of cardiovascular events and death, but only in the case of those with hypertension. This study also reported associations between low salt intakes and increased risk of cardiovascular events and death in both hypertensives and normotensives [31]. While the optimal lowest intake of salt is still being debated, there is no question that in most countries, population-level estimates of salt far exceed the recommendation of a maximum 5 g/day, thus, necessitating salt reduction strategies [20].

In 2004, the WHO released its “Global Strategy on Diet, Physical Activity and Health” that was adopted by the World Health Assembly and which called upon all governments and stakeholders to work towards improving the healthfulness of diets [32]. More recently, WHO member states have agreed to work towards voluntary targets to reduce NCDs by 25% by 2025, with one of the nine global targets being a reduction in population salt intake by a relative 30% [22].

In order to develop national policies and strategies to lower population-level salt intake in LMICs, it is necessary to have an understanding of the main dietary sources of salt. This information is required to assist governments to enact policies and programs, and to concentrate on particular food items that are of relative importance to excessive salt consumption in LMICs. The aim of this systematic literature review is to identify the major food sources that contribute to salt consumption in populations in LMICs.

2. Materials and Methods

A literature search was conducted in March 2017 using the Medline, Web of Science, and Scopus databases. Hand searching of the reference lists was performed from articles retrieved from these databases. Grey literature was also searched by visiting institution and government websites and other sources. Data collected were synthesized according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [33] (Figure 1). The research question investigated was: “What are the dietary sources of salt in LMICs?” Search terms are listed in Supplementary Materials Table S1.
Outcome measures included dietary sources of Na/salt. Only articles reported in English were included. All countries in the LMIC bracket were listed among the search terms. Low-income economies were defined as those with a gross national income (GNI) per capita, calculated using the World Bank Atlas method, of $995 or less in 2017; lower middle-income economies were those with a GNI per capita between $996 and $3895; and upper middle-income economies were those with a GNI per capita between $3896 and $12,055 \cite{34}. The search was restricted to articles published from 1960 onwards.

![Prisma Flow Diagram](image)

**Figure 1. PRISMA 2009 flow diagram.**

Data extraction was completed by the lead author (EM) and reviewed by the second author (KC). Endnote X4 (Clarivate Analytics, Philadelphia, PA, USA) was used to manage the citations. Each article was ranked for level of evidence using the National Health and Medical Research Council (NHMRC) recommendations \cite{35}. A narrative synthesis of the studies was completed because of the heterogeneity in reporting outcomes of the studies. In this literature review, Na and salt were used interchangeably. Studies were included if a study (a) reported actual quantities of Na/salt in foods and (b) data were collected from food diaries, diet recall, food frequency tables or laboratory analysis of salt content in food, and (c) laboratory analysis of salt content in food.

Data were extracted by first reviewing the title and selecting abstracts of those with relevant titles. If the abstract met the inclusion criteria, the full article was retrieved (see Figure 1). Studies were summarized according to descriptive characteristics, including the region, country, data collection
period, study emphasis, and the study design. Each paper was categorized also by the author, population, outcome measured, method of measurement, and the results. Quality rating was conducted using appraisal tools for cross-sectional studies for nine articles that utilized a human population [36] (Supplementary Materials Table S2). This systematic review was registered with the International Prospective Register of Systematic Reviews (Prospero CRD42016038173).

3. Results

Our search of databases and additional records yielded 3237 titles. One-hundred-and-seventy-seven abstracts (23 hand-searched) were retrieved after duplicates and irrelevant papers were excluded, thereafter resulting in 34 full papers being assessed for eligibility and inclusion. Of these 34 articles, 15 were included in the final review. Reports from the country level WHO Stepwise Surveillance surveys were hand-searched but did not yield relevant information. Figure 1 shows the PRISMA flow diagram providing details of the search and included studies.

Of the final included articles grouped according to WHO-defined geographical regions [37], the greatest number of articles (i.e., four each) were from Africa and the Western Pacific (though in the Western Pacific region, all the articles came from China), whereas the least number of the articles (i.e., one) came from European countries (Supplementary Materials Table S3). Fifteen of the included studies were conducted in 12 countries and most of them had been published within the last two decades (1991–2016). Six of the articles did not report data collection periods. With the exception of one randomized controlled trial, all other studies were cross-sectional and descriptive in design and concentrated on dietary behavior and product reformulation.

Analytical values for the salt content of bread were reported in five articles (Table 1). Zibaeezehad et al. [38] included the highest number of samples of bread that were examined, whereas Ferrante et al. [39] recorded the greatest number of bakeries that were sampled within one study. For studies that included samples of bread from different suburbs and locations, salt content varied depending on the municipality and producer. The highest salt content found in bread was 1.80 g/100 g in Nigeria [40]. The average salt content in bread from all articles was more than the voluntary targets and recommended quantities in other countries (380–400 mg Na per 100 g bread) [41–43]. One study from Ferrante et al. [39] analyzed salt content in French bread, croissants, and cookies and crackers using dietary recall and additionally used biochemical analysis for French bread. Results from the two methods used for French bread indicated an underestimation of salt use with the dietary recall. Financial constraints did not permit chemical analysis of the other food items.

There were three articles that reported salt content of additional foods other than bread, including preserved fish, cookies, crackers, as well as water (Table 2) and seven articles assessed total dietary salt intake (Table 3). Two of the included articles [44,45] investigated children’s dietary salt intake. Four of the articles that measured dietary intake also included biomarkers of participants’ 24 h urinary Na excretion [46–49]. The major sources of dietary salt were breads, meat and meat products, bakery products, noodles, salted preserved foods, milk and dairy products, and condiments. Additionally, some articles reported that a high amount of salt in the local diet came from discretionary salt [45,49,50], but this was not consistently measured.
Table 1. Summary table of studies that reported salt content of bread by chemical analysis.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Population</th>
<th>Outcome Measured</th>
<th>Method of Measurement</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silva et al., 2015</td>
<td>All bakeries (n = 17) situated in Maputo city that were listed in the Mozambican Yellow Pages were included.</td>
<td>Na content in bread.</td>
<td>Flame photometry</td>
<td>Mean Na content of bread was 450 mg/100 g, ranging between 255 mg/100 g and 638 mg/100 g, with no significant differences between bakeries and traditional markets. Mean Na &gt; a, b, and c.</td>
</tr>
<tr>
<td>Nwanguma and Okorie, 2013</td>
<td>Retail samples of 100 brands of white bread made from wheat flour, representing the major brands were purchased from 30 standard retail outlets in Nassau and Enugu towns, both in Enugu State in South-Eastern Nigeria.</td>
<td>Na content in bread.</td>
<td>Flame photometry</td>
<td>Mean Na = 544 mg/100 g. Na ranged from 396 mg to 1332 mg/100 g. Mean Na &gt; a, b, c, and d.</td>
</tr>
<tr>
<td>Hussain and Takouri, 2016</td>
<td>68 samples of seven types of bread were collected from 13 different bakeries in the city of Amman, Jordan.</td>
<td>Na content in bread.</td>
<td>Flame photometry</td>
<td>Mean Na content = 476 ± 84 mg/100 g, ranging between 168 ± 20 mg for * White Arabic bread to 824 ± 76 mg/100 g for * shank bread. Mean Na &gt; a, b, and c.</td>
</tr>
<tr>
<td>Zibaeezehad et al., 2010</td>
<td>204 bakeries in districts of Shiraz city in Iran; 408 bread samples were collected from bakeries, measuring the salt content of 6 different kinds of bread.</td>
<td>Na content in bread.</td>
<td>Laboratory testing of salt percentage in bread as outlined by Iran’s Organization for Standards and Industrial Investigations [53]</td>
<td>Mean Na = 524 mg/100 g ranging from 0-1400 mg/100 g bread. Mean Na &gt; a, b, c, and d.</td>
</tr>
<tr>
<td>Vukčić et al., 2013</td>
<td>12 samples of bread purchased in stores from the 3 municipalities: Bijeljina, Zvornik, and East Sarajevo in Bosnia. In each municipality 8 samples were randomly selected.</td>
<td>Na content in bread.</td>
<td>Atomic absorption spectrophotometry (AAS) using an instrument VARIAN Spectr AA-10 [53]</td>
<td>Mean Na = 405 ± 177 mg/100 g, 489 ± 174 mg/100 g, and 673 ± 119 mg/100 g for East Sarajevo, Bijeljina, and Zvornik, respectively. Bread samples from East Sarajevo, mean Na &gt; a and b. Bread samples from East Bijeljina, mean Na &gt; a, b, and c. Bread samples from East Zvornik, mean Na &gt; a, b, c, d, and e.</td>
</tr>
<tr>
<td>Ferrante et al., 2011</td>
<td>25,000 bakeries countrywide affiliated to Argentinean Federation of Bakeries.</td>
<td>Na content in bakery products.</td>
<td>Dietary recall and flame photometry</td>
<td>Self-reported (using food composition table) mean Na content of French bread = 1.8% (range 1.0% to 4.0%), chemical analysis of French bread, mean Na concentration = 2.0% (range 1.4% to 3.0%) of total salt intake. Mean Na &gt; a, b, c, d, and e.</td>
</tr>
</tbody>
</table>

*White Arabic and shank bread are bread types in Amman, 2% Na ≈ 4 g. of total salt intake. a > 380 mg/100 g—maximum level of Na in bread established by the South African Government; effective June 2019 [41]. b > 400 mg/100 g—maximum level of Na in bread recommended by the Government of Australia [42,43]. c > 450 mg/100 g—maximum level of Na in bread recommended by the National Heart Foundation of New Zealand [42]. d > 490 mg/100 g—Level of Na that is required by the Finnish Government for the designation of “highly salty” on a label [56]. e > 550 mg/100 g—maximum level of Na in bread established by the Portuguese Government [57].
Table 2. Summary table of studies that assessed consumption of salt from specific foods and water.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Population</th>
<th>Outcome Measured</th>
<th>Method of Measurement</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kerry et al., 2005 [46]</td>
<td>12 villages (6 rural, 6 semi-urban) were chosen in Ghana. Between 95 and 250</td>
<td>Frequency of consumption of high salt</td>
<td>Food frequency questionnaire asked about the consumption of five salty foods: koobi,</td>
<td>92% reported eating salted fish. While salted meat (pig's feet and beef)</td>
</tr>
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<td></td>
<td>subjects aged 40-75 years from each village, for a total 1896, selected by</td>
<td>foods.</td>
<td>momoni, koko (all salted fish), salted pig's feet, and salted beef. Also questioned</td>
<td>was eaten more often by semi-urban villagers, salted fish was eaten</td>
</tr>
<tr>
<td></td>
<td>stratified random sampling from a census of all inhabitants of the village.</td>
<td></td>
<td>the use discretionary salt, stock cubes or monosodium glutamate (MSG).</td>
<td>more often by rural villagers. Majority of the respondents (98%)</td>
</tr>
<tr>
<td>Ferrante et al.,</td>
<td>25,000 bakeries countrywide affiliated to Argentinean Federation of</td>
<td>Na content in bakery products.</td>
<td>Dietary recall and Flame photometry.</td>
<td>frequently added salt to food in cooking.</td>
</tr>
<tr>
<td>Khan et al.,</td>
<td>343 pregnant Dacope women from Bangladesh recruited for a pilot phase of</td>
<td>Na intake from drinking water sources</td>
<td>Indirect estimates of individual salt and intake from groundwater and river water,</td>
<td></td>
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<td></td>
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<td>Information System (CEGIS) in Bangladesh.</td>
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</table>

Note: 5 g/d salt = 2000 mg Na, 2% Na = 4 g of total salt intake.
Table 3. Summary table of studies that assessed total salt intake using dietary assessment methods.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Population</th>
<th>Outcome Measured</th>
<th>Method of Measurement</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charlton et al., 2005 [49]</td>
<td>300 men and women from three different ethnic groups (black, mixed ancestry, and white), aged 20 to 65 y, conveniently sampled from place of work, Cape Town City Council, South Africa. Equal numbers of hypertensive (BP ≥ 140/90 mm Hg and/or on antihypertensive medication) and normotensive (BP &lt; 140/90 mm Hg) men and women were planned (n = 150/group, 50 from each ethnic group).</td>
<td>Dietary intake of Na.</td>
<td>Interviewer administered 3 repeated 24 h recalls. Standard household measuring utensils, rulers, and food photographs of typical South African foods [58] used to quantify food portion sizes. The average daily nutrient intake calculated using Foodfinder III computerized dietary assessment program, based on Medical Research Council Food Composition Tables [59].</td>
<td>In all three subsamples, cereals were the main contributor to total reported dietary Na intake (45.9% to 48.6%), followed by meat and meat products (20.3% to 23.6%) and milk and dairy products (6.3% to 8.1%). In all groups, bread was the major source of dietary Na (25.2% to 40.5%).</td>
</tr>
<tr>
<td>Liu et al., 2014 [48]</td>
<td>726 Chinese post-menopausal women who attended a screening visit for a randomized controlled trial testing the effect of soy products supplementation on BP were conveniently sampled.</td>
<td>Dietary intake of food substances from which Na content was determined.</td>
<td>A 3-day food records questionnaire was used to estimate dietary nutrients intake. Food items were those most frequently consumed based on previous local surveys [40,41]. Subjects received a 30 min training on estimation of food amounts, portion, and usual sizes. Dietary nutrients were calculated based on the China Food Composition Table and local Na database [62,63]. Total Na intake was calculated by summing the estimates from all contributory food items or groups.</td>
<td>Major sources of non-discretionary salt include soup (21.6%), rice and noodles (13.5%), baked cereals (12.3%), salted/pre-served foods (10.8%), Chinese dim sum (10.2%), and sea foods (10.1%) of the total salt intake.</td>
</tr>
<tr>
<td>Zhao et al., 2015 [43]</td>
<td>903 families were conveniently sampled for the study. 2952 participants were recruited from families in urban (Xicheng District) and suburban (Huaqiao District) Beijing, China. Study families were recruited through public primary and junior high schools. Eligible families were those with a child from the enrolled schools.</td>
<td>Dietary salt intake and sources of salt in the diet.</td>
<td>A simplified “one-week salt estimation method” was designed to measure each family member’s daily salt intake and determine the sources of salt in the diet. This method estimates salt intake from three sources: household cooking, processed food, and caterers or restaurants. The methodology was previously published [43].</td>
<td>Soy sauce, vinegar, other sauces and MSG contributed 47%, 34%, 12%, and 7% to total Na intake. The mean Na intake was 5360 (SD 3320) mg/day. Adults consumed more Na 6900 (SD 3640) mg/day than children and adolescents 4400 (SD 2485) mg/day and senior citizens 4090 (SD 1920) mg/day.</td>
</tr>
<tr>
<td>Health Promotion Board, Singapore, 2011 [65]</td>
<td>Singaporean National Nutrition Survey 2010, comprised 739 subjects aged 18-65 years conveniently sampled.</td>
<td>Na content in selected foods.</td>
<td>Face-to-face interviews were conducted where dietary practices and food frequency questionnaires were administered. Nutrients and various food groups were assessed by comparing the levels of intake with dietary standards including the Recommended Dietary Allowances (RDAs).</td>
<td>Fish balls, fish cakes, breads, and noodles were estimated to contribute 37% of the population’s salt intake. Daily Na intake was 3265 mg/day.</td>
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Table 3. Cont.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Population</th>
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<th>Results</th>
</tr>
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<tbody>
<tr>
<td>Du et al., 2014 [66]</td>
<td>Secondary data from China Health and Nutrition Survey (1991–2009) comprising 16,869 adults aged 20–60 y were used.</td>
<td>Na intake from foods and condiments.</td>
<td>These consecutive 24 h dietary recalls in combination with weighing methods. All foods and condiments recorded and measured. Na intake (i.e., Na from all foods and condiments) were based on their compositions in the Chinese food-composition table.</td>
<td>The average soy sauce intake was 6.9 g/d, accounting for 8.5% of total Na intake. The average processed food intake was 244.7 g/d, which represented 20.8% of all food consumed and accounted for 6.8% of total Na intake. The average MSG intake was 1.5 g/d, accounting for 3.4% of total Na intake.</td>
</tr>
<tr>
<td>de Moura Souza, 2013 [44]</td>
<td>Nationwide dietary survey: Food consumption of a representative sample of the Brazilian population 10 years of age or older (n = 34,003).</td>
<td>Na content in foods and beverages.</td>
<td>24 h dietary recall using the nutrition data system for Research software version 2008, the Brazilian Food Composition Table [67], and Brazilian studies on regional foods [68].</td>
<td>Foods with high Na densities (&gt;600 mg/100 g) included salty preserved meats (997 mg/100 g), processed meats (974 mg/100 g), cheeses (883 mg/100 g), crackers (832 mg/100 g), sandwiches (880 mg/100 g), pizza (729 mg/100 g), and breads (646 mg/100 g), as well as oils, spreads, sauces, and condiments (884 mg/100 g). Altogether these food groups contributed 25% (811 mg/100 g) of the average daily Na intake. The mean Na intake was 3190 mg/day.</td>
</tr>
<tr>
<td>Anderson et al., 2010 [69]</td>
<td>Participants were 4880 women and men aged 40 to 59 years, recruited by stratified random sampling from 17 diverse populations—community-based or workplace-based—in Japan (four samples), People’s Republic of China (three rural samples), the United Kingdom (two samples), the United States (eight samples).</td>
<td>Na intake was calculated by summing estimates from all contributory food sources, including foods and beverages, ingested at home or away from home.</td>
<td>24 h dietary recall. No content of each food item was determined using the enhanced national food database for each country.</td>
<td>For China, mean Na intake = 3990 ± 1943 mg/person/day; Soy sauce = 256 mg/person/day, mustard, turnip greens, and cabbage = 143 mg/person/day, sodium bicarbonate and sodium carbonate (tenderizer) = 98 mg/person/day, and noodles were 99 mg/person/day. Japan, mean Na intake = 465 ± 1279 mg/person/day. United Kingdom mean Na intake = 3406 ± 1162 mg/person/day, and United States mean Na = 3660 ± 343.1 mg/person/day.</td>
</tr>
</tbody>
</table>

Note: 5 g/d salt = 2000 mg Na, 2% Na = 4 g of total salt intake.
4. Discussion

To reduce population salt intake, the WHO “SHAKE the Salt” framework strongly emphasizes a need to identify major sources of salt in the diet and to embark on strategies that include product reformulation, taxation, nutrition labeling, and nutrition education [69]. The current review has identified bread as the major food source that provided the highest amounts of salt to the diets of populations in 12 LMICs. Meat and meat products, salted meat and fish, sauces, spreads, condiments, pizza, sandwiches, seafood, and ground or river water were also identified as major contributors to non-discretionary salt intake. Contribution of each of these foods differs by cuisine of the country, for example among Asian countries, sauces and MSG are prevalent [45,50,66], whereas in Africa and Latin America it is bakery, meat, and dairy products [40,44,49].

The average Na content for bread was above 400 mg per 100 g bread, which exceeded the generally accepted target for salt content of bread [41–45,70]. Similarly, in high-income countries such as Australia, some loaves provide more than 25% of the maximum daily recommended intake of salt in just two slices [71], with bread and bread rolls contributing 25% of total salt provided by processed foods [72]. The consumption of bread has increased in LMICs [73] due to the decline in traditional staples such as maize, millet, and sorghum to the rise in wheat [74]. In India, the production of wheat increased from 75.81 million MT in 2007 to 94.86 million MT in 2012 [75], while Pakistan experienced a 3.2% increase between 2012 and 2013 [76]. Food preferences have changed and this has altered the consumption of traditional staples. Relatively, there has been a global shift in dietary patterns from the reliance on traditional staples to processed foods due to the increased production of processed foods and changing lifestyles [20]. The Food and Agriculture Organization predicts that with the rise in income levels, preference for wheat products will increasingly overshadow traditional coarse grains [77]. In many LMICs, wheat is gradually replacing roots and tubers [78]. Furthermore, rapid urbanization in LMICs is changing diets such that “fast foods” (ready-to-eat), which typically contain excess salt, have replaced core staple plant-based foods, thereby increasing the demand for processed foods [79]. Other reasons for shifts to a greater reliance on processed foods may be related to an increase in the number of women in the workforce, which has affected roles within the household related to food preparation [80]. The rising trend of eating away from home or eating prepared food away from home has contributed to the increased consumption of bakery products [81,82] in urban settings. Bread has virtually become a staple food [83], and which for many, forms the basis of breakfast, lunch, and dinner. For example, in some parts of the Democratic Republic Congo, bread has substituted cassava, the traditional starchy staple used in preparing “fufu” (dough made from boiled and ground plantain or cassava) [84]. Similarly, bread intake is higher than traditional staples in southern Mozambique [85,86] and is widely eaten as a snack or as a complete meal in Nigeria [87]. Bread is easily accessible from stores and vendors and more convenient than traditional cereal and root staples, both of which require time and effort for preparation before consumption. In the Seychelles, there has been a decreased consumption of the traditional staple (fish) as a result of increased intake of meat, poultry, processed meat, and snacks [88].

There have been major increases in meat (i.e., beef, pork, and poultry) in LMICs [89,90], including processed meat that is high in salt [91,92]. Increased consumption of processed meat products has the potential risk of coronary heart disease, type-2 diabetes, and colorectal cancer [93,94]. In Australia, processed meat contributed 10% of daily Na intake [95] and is described as being a major contributor to salt intake in the United Kingdom [96]. Bacon for example, contains more than twenty times the quantity of salt compared to fresh pork of the same weight [97]. As countries are becoming more economically wealthy, there has been an increased demand for animal source products with livestock being one of the fastest growing agricultural subsectors in LMICs [98], and accompanying advancement in food technology in these countries resulting in increased availability of processed animal products. These processed animal products may be contributing to the increase in salt intake within LMIC populations. A potential strategy to reduce salt intake would be to reduce processed meat intake. This would have the additional benefit of reducing climate change issues such as high greenhouse
gas emissions from cattle and diverting agricultural land use from human consumption to animal consumption [99,100].

Highly palatable, energy-dense, low-cost, ultra-processed foods, snacks, and beverages are commonplace within the food supply in LMICs [101,102]. This is evident in the growing number of supermarkets that are replacing open public markets in LMICs [103]. Consumers are attracted to these foods because of their affordability, ease of access, availability, and taste, which are often accompanied by intensive marketing by the food industry sector [103], particularly in poorer environments where alternatives are limited [104].

In most LMICs, food security is a major issue and food preservation using salt is commonplace. In these countries, food production is seasonal but in greater quantities during harvest, after which production dwindles significantly [14,15]. Ghana, for example, experiences two rainy seasons a year (with the major one in June and the minor in October) and these are the times for crop production in most parts of the country [105]. The major fishing season shares the same timeframe [106,107]; thus, the bulk of the country’s food supply is produced in one-half of the year, thereby warranting preservation, one of which is using salt [108] to ensure its availability and maintenance for off-season supply [14,15].

An often under-estimated source of dietary salt relates to the contribution from the water supply. Studies on river and underground shallow water salinity are lacking in the face of severe drought in LMICs [109–111]. More challenging is the fact that there are no guidelines for safe salinity levels in drinking water [21]. During the dry season in Bangladesh, it is estimated that up to 5–16 g salt per day may be consumed from river and shallow underground drinking water [47]. There are many places in Africa and Asia where the sources of water are unsafe for human consumption [112–114] and the likelihood for excess salt provided by water bodies remain high as environmental and climatic conditions worsen [115]. This issue has been ignored in recommended global strategies [20] to reduce population-level salt intake.

The shift in dietary patterns is also driven by the promotion of Western culture through media outlets, international trade, and other channels related to globalization [74]. Many supermarkets, hotels, restaurants, and fast food outlets in LMICs are multinational establishments that provide the same menu as their partners in higher-income countries. These food outlets are a major driving force changing the food environment and dictating food preferences in LMICs [12]. Globalization of food systems in this way, undermines traditional dietary practices and creates an avenue for food and nutrient insecurity. Greater availability and access to these cheap, imported, energy-dense, nutrient-poor foods have culminated in an increased prevalence of obesity and a myriad of NCDs plaguing many African countries (that are already burdened with infectious diseases) [116]. A challenge is for LMICs to consider agriculture within economic growth and development, to ensure that food insecurity is not exacerbated by increasing urbanization. A deliberative approach should be developed and geared towards the production, availability, accessibility, and consumption of a wide range of traditional staples in the face of rapid development. Countries in South East Asia provide exemplars as they have encouraged and improved the traditional cuisine to meet current developmental changes [117,118]. The United Nations’ Sustainable Development Goals provide a framework against which country progress towards 17 goals will be reported by governments [119]. Partnerships and global solidarity between countries should include commitments by major food companies to limit and standardize acceptable maximum limits of harmful components allowed in imported or branded foods sold across the globe and prevent dramatic differences currently seen in the salt content of similar products and fast food meals across countries.

An urgent need to address food systems in LMICS is required in order to stem the pandemic of NCDs, as more than three-quarters of premature NCD deaths occur in these countries [20]. South Africa serves as an example where the government has mandated maximum salt levels permitted across a wide range of processed foods, in an effort to reduce the burden of hypertension [8,120,121] and its related morbidities [122]. Though the impact of this legislation is yet to be demonstrated [123], it is seen as a bold step towards saving lives and reducing health care costs [124,125]. The WHO has
emphasized that government policies and programs, collaboration with private sector organizations, and monitoring of population salt intake are key measures to population salt reduction [20].

Understanding salt use behaviors at the population level is required in order to determine best approaches to salt reduction in countries [126]. Many governments have focused on individual consumer behavior change [127], focusing on salt added at the table and during cooking. Though commendable, a multi-faceted approach which targets both discretionary and non-discretionary salt use is encouraged [20]. This review collated the available information on dietary sources of salt in LMICs in an effort to identify the food sources that contribute to total salt intake. Many LMICs do not have reliable assessments of dietary salt intake nor do they have national targets and timelines towards ensuring a decline in salt consumption. This makes it challenging to assess progress towards achieving the WHO’s voluntary salt reduction target of a relative 30% by 2025 [20]. Advocacy by civil society groups, organizations, institutions, and professional health associations for salt reduction in foods is required to lobby governments whose health agenda does not include changes to the food supply. This approach has been demonstrated by the Australian Division of World Action on Salt and Health, whose efforts have resulted in voluntary salt targets for the food industry [71]. The legislative approach adopted by the South African government [41] may serve as blueprint for LMICs [128].

Limitations to the review relate to the selection criteria being based on the English language only. This may have limited the scope of the search and subsequent data retrieved for consideration. Nonetheless, studies included covered all WHO global regions. Many of the cited papers did not provide information on the actual dietary consumption patterns of the populations residing in the areas from where the food samples were obtained. This means that overall contribution of individual foods to total salt intake could not be determined.

5. Conclusions

Processed foods that have a high salt content are becoming commonplace in the diets of populations in LMICs. Major sources of salt are provided by bread, meat and meat products, salted meat and fish, sauces, spreads, condiments, pizza, and seafood. Differences exist between WHO regions regarding sources of food products that contribute to total salt intakes. Water sources in drought-affected areas also warrant further attention as sources of Na intake. Besides foods that contain high salt, discretionary salt use is widespread in LMICs.

Supplementary Materials: The following are available online at http://www.mdpi.com/1660-4601/16/12/2082/s1, Table S1: Search strategy, Table S2: Risk of bias assessment, Table S3: Included articles and their regions of origin.

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Appendix G - Salt Use Behaviours of Ghanaians and South Africans: A Comparative Study of Knowledge, Attitudes and Practices

Salt Use Behaviours of Ghanaians and South Africans: A Comparative Study of Knowledge, Attitudes and Practices

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Abstract: Salt consumption is high in Africa and the continent also shares the greatest burden of hypertension. This study examines salt-related knowledge, attitude and self-reported behaviours (KAB) amongst adults from two African countries—Ghana and South Africa—which have distributed different public health messages related to salt. KAB was assessed in the multinational longitudinal World Health Organisation (WHO) study on global AGEing and adult health (SAGE) Wave 2 (2014–2015). Respondents were randomly selected across both countries—Ghana (n = 6746; mean age 58 years old; SD 17; 41% men; 31% hypertensive) and South Africa (n = 3776; mean age 54 years old; SD 17; 32% men; 45% hypertensive). South Africans were more likely than Ghanaians to add salt to food at the table (OR 4.80, CI 4.071–5.611, p < 0.001) but less likely to add salt to food during cooking (OR 0.16, CI 0.130–0.197, p < 0.001). South Africans were also less likely to take action to control their salt intake (OR 0.436, CI 0.379–0.488, p < 0.001). Considering the various salt reduction initiatives of South Africa that have been largely absent in Ghana, this study supports additional efforts to raise consumer awareness on discretionary salt use and behaviour change in both countries.

Keywords: discretionary salt; dietary salt; sodium; health behaviour; blood pressure

1. Introduction

The Global burden of Disease study has demonstrated that diet contributes significantly to risk of non-communicable diseases (NCDs) such as cancer, cardiovascular disease (CVD) and diabetes [1]. Dietary risk factors include diets low in fruits, vegetables, whole grains, nuts and seeds, fibre, omega-3 oils, and polyunsaturated fatty acids and diets that are high in sodium, red meat, processed meat, sweetened beverages, and trans fats [2–6]. The nutrition transition in many Sub-Saharan countries is resulting in a change in dietary patterns from traditional, plant-based diets to increasing intakes of processed foods that tend to be high in sugar and/or fat, known as energy dense, nutrient poor (EDNP)}
foods that are generally also high in salt [7]. Excess salt intake has been identified as one of the leading global health risks [8] and population level salt reduction is recognized as a cost-effective means of reducing blood pressure [9-12] and, in turn, reducing the risk of heart disease and stroke [13,14]. A 30% reduction in population level salt by 2020 is one of the voluntary global health targets identified by the World Health Organization [7].

On a global scale, it has been estimated that 1.7 million lives could be saved annually if salt consumption levels were decreased to recommended levels of less than 5g per day [15]. Across high and low-middle income countries, interventions to reduce population salt intake are considered cost effective (less than $1USD per person per year) [16,17].

Over 75% of cardiovascular deaths take place in low and middle-income countries [18] with the African region estimated to have around 20 million people with CVD [18]. As such, Africa shares the greatest burden of hypertension with almost half of adults aged 25 and older diagnosed and potentially more adults with undiagnosed, untreated and uncontrolled hypertension [19]. In Ghana, the prevalence of hypertension has continued to rise over the past 40 years [20-22]. South Africa (SA) equally shares a large burden of hypertension [23,24]. The direct healthcare costs attributable to non-optimal blood pressure in Sub-Saharan Africa (SSA) in 2001 were estimated to be two billion US dollars [25].

More than two-thirds of African populations attach low importance to dietary salt reduction as a significant approach to addressing hypertension [26,27]. In most African countries, salt is commonly added to food at the table and during cooking, and is a major ingredient found in commonly used sauces and seasonings [28,29]. Salted fish and meat are eaten frequently [30] while bread contains levels of salt that are generally higher than in countries in Europe and North America [31,32]. In SA, other sources of salt include cereals, meat and meat products, milk and dairy products, processed meats, meat pies and margarine. In that country, it is estimated that discretionary salt intake accounted for almost half of the total dietary intake in a sample of black urban dwelling people [33]. This represents a greater contribution as compared to many high income countries, where 75-85% of dietary salt intake is estimated to come from processed foods [34]. The Ghana Demographic and Health Survey indicated that 84% of women surveyed reported that someone in their household had consumed processed foods containing salt within the past 24 hours, while more than a third had consumed salted dried fish, 21% reported having had canned fish, meat and legumes and 24% reported the use of other processed foods containing salt [35]. The report identified a high use of salty foods in both rural and urban areas. Similarly, the South African Demographic and Health Survey 2003 indicated that more than 30% of survey respondents reported adding salt to food at the table and consuming salty snacks more than twice a week [36].

To reduce discretionary salt consumption in SA, there has been a concentrated focus on consumer education and awareness in recent years [37]. In addition, in June 2016, the SA government implemented mandatory legislation related to maximum levels of salt permitted in a wide range of processed food categories, including breads, meat, cereal products, fat spreads, snack foods and savoury products [38]. These foods have previously been shown to contribute significantly to overall non-discretionary salt intake in the South African population [33]. In contrast, in Ghana, there have been no concerted efforts by government or non-governmental organizations to implement salt reduction strategies. Instead, there has been a focus on the prevention of iodine deficiency through universal salt iodisation programmes [39-41] with the message to consume iodized salt widely disseminated through the mass media [39]. Public health concerns related to the association between increased salt intake and cardiovascular risk in Ghana have received comparatively little attention despite promising proof of concept studies [42]. Iodisation programmes and salt reduction strategies are not mutually exclusive, as has been demonstrated [43]. However, for both programmes to successfully coexist, different sectors of government (nutrition and NCDs) need to work together, to effectively monitor the iodine status of populations as salt content in the food supply decreases.

Given that the population in Ghana has been urged to consume iodised salt [39,40,44] combined with the generally increased accessibility of EDNP processed foods, it is timely to investigate knowledge, attitudes and behaviours (KAB) related to salt use in Ghana and to compare these against
SA, an African country in which salt reduction has been strongly emphasized. Ghana and SA share similar socio-demographic characteristics, as well as a high hypertension burden. The findings will be important—particularly for low and middle-income countries—for informing approaches to reducing the health risks through a better understanding of salt intake behaviours.

2. Materials and Methods

2.1. Study Design

Analysis for this study utilizes two nationally representative datasets collected in Ghana and South Africa (SA) during the World Health Organization’s Study on global Ageing and adult health (SAGE-Wave 2) [45]. WHO SAGE is a multinational prospective cohort study that has been conducted in six low and middle-income countries since 2002. The purpose of the study is to examine the health and wellbeing of adults and the ageing process, with the aim of responding to health needs through policy, planning, and research. SAGE Wave 2 was conducted in Ghana and SA in 2014/2015 with Wave 3 to be implemented in 2017–2018.

2.2. Participants

A total of 10,522 adults were recruited; 6,746 in Ghana and 3,776 in SA. Stratified sampling was conducted to respondents aged 50 years and older, with approximately 30% of adults aged 18–49 years as a comparative cohort. In selecting the sample, all SAGE Wave 1 households were included for SAGE Wave 2 data collection [45]. In SAGE SA, replacements for sample attrition used a systematic sampling approach to randomly select new households as previously described [46]. The sampling method used in SAGE Ghana followed a similar design, based on the 2003 World Health Survey/SAGE Wave 0 [47] with primary sampling units (PSUs) stratified by region and location (urban/rural). Selection of the PSUs was based on proportional allocation by size using the same follow-up and random systematic sampling method as South Africa.

2.3. Data Collection

Data collection in Ghana was completed by four field teams each comprising of 3–5 field workers who moved from region to region over an 11-month period (September 2014 to June 2015). In SA, twenty survey teams collected data from respondents across all provinces in the country over a 5-month period (August to December 2015). Surveys were administered in participants’ home language. A computer assisted personal interview was used in collecting the data. All survey teams were trained with support from the WHO SAGE team, with survey teams using standardized training and survey materials [45]. Field teams visited respondents in their homes and workplaces to administer interviews.

2.4. Study Measures

The main outcome of the current analysis relates to reported salt KAB captured using a five-item questionnaire adapted from the WHO/PAHO protocol [48]. KAB is the usual term for such research and has been widely used, including in the context of salt behaviours [48–52]. One question investigated knowledge about salt and health—“Do you think that a high salt diet could cause a serious health problem?”—with answer options “yes” or “no”. Another investigated attitudes about salt—“How much salt do you think you consume?”—with answer options of “far too much,” “too much”, “just the right amount”, “too little”, “far too little”, “don’t know”, and “refused”. The congruence between attitudes and perceptions has been explored [53], but for the purposes of comparison with other studies we prefer to retain the terminology of “attitudes”. Three questions assessed salt use behaviours: (1) “Do you add salt to food at the table?”; (2) “In the food you eat at home, salt is added in cooking?”; and (3) “Do you do anything on a regular basis to control your salt or sodium intake?”—with answer options “always”, “often”, “sometimes”, “rarely”, and “never” for items 1 and 2, and “yes”, “no”, “don’t know”, and “refused” for item 3. Likert type response scales
were provided, but for analysis of responses to the salt use behaviour questions categories of “always” and “often” were combined to represent “frequent” use, whilst “rarely” and “never” were combined to represent “infrequent” use.

“Currently working” was recorded as “having worked for at least 2 days during the last 7 days”. “Recent use of alcohol” was recorded as “having consumed alcohol in the last 30 days”, while “frequent alcohol intake” was recorded as “having consumed at least one alcoholic drink (on average) one or more days in a week” and “infrequent alcohol intake” was recorded as having consumed at least one alcoholic drink (on average) one to three days per month.

Age, sex, residential location (urban/rural), education, marital status, employment status, alcohol intake, smoking status, blood pressure (BP) and salt behaviour variables were recorded, as shown in Table 1. BP was measured using wrist worn validated Omron BP devices with omni-directional sensors (Amron R6, Kyoto, Japan) [53]. Three BP readings were recorded on the left wrist (1-min between each measurement) while the participant sat with the wrist precisely at the level of the heart and legs uncrossed.

2.5. Ethics

Prior to data collection, the study measures were explained to the participants in their home language by the fieldworkers and written informed consent was obtained. The study complied with the ethical principles for medical research involving human subjects as stated in the Declaration of Helsinki [54]. The WHO Research Ethics Review Committee approved the study [RPC149]. Local ethical approval was obtained from the North-West University Human Research Ethics Committee (Potchefstroom, South Africa), the University of the Witwatersrand Human Research Ethics Committee (Johannesburg, South Africa), and the University of Ghana Medical School Ethics and Protocol Review Committee (Accra, Ghana).

2.6. Statistical Analysis

All data were collated and analysed using IBM SPSS Statistics for Windows, Version 20.0. (IBM Corp., Armonk, NY, USA). The normality of the data was checked by visual inspection and the Kolmogorov-Smirnov test. Descriptive statistics of frequencies, percentages and median (IQR) were used to describe respondents’ characteristics and responses to survey items. Country differences were evaluated using Chi-square and Independent Samples Mann Whitney U tests. The significance level was set at p < 0.05. Logistic regression was applied to compare the probability of various salt behaviours between Ghana and SA and odds ratios and 95% confidence intervals (95% CI) were computed. The model was adjusted for potential confounders which included age, sex, residential location, educational level and hypertension prevalence as demonstrated in other studies [52,55–57]. BMI was not included in the final regression model as it was not statistically significant.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Age Categories—Countries Combined</th>
<th>Ghana</th>
<th>South Africa</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>18–49 Years Old (n = 2279)</td>
<td>50+ Years Old (n = 5869)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age in years, median (IQR)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50 plus years, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex male, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residence urban, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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|-------------|--------------|--------------|---------|
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|             | | | | |
|             | | | | |
Table 1. Cont.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Age Categories—Countries Combined (n = 2279)</th>
<th>Ghana (n = 573)</th>
<th>South Africa (n = 392)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ever attended school, n (%)</td>
<td>n = 2088 (93.2)</td>
<td>n = 4734</td>
<td>n = 2920</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Educational level high school or above, n (%)</td>
<td>n = 1899 (93.2)</td>
<td>1964 (81.4)</td>
<td>2462 (82.3)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Employment status: currently working, n (%)</td>
<td>n = 1471 (66.5)</td>
<td>n = 4537</td>
<td>n = 1766</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Marital status: married/cohabiting, n (%)</td>
<td>n = 937 (41.9)</td>
<td>2692 (86.8)</td>
<td>1915 (51.5)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Waist-to-height ratio &lt;0.5, n (%)</td>
<td>n = 1085 (48.0)</td>
<td>n = 4347</td>
<td>n = 2131</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Body Mass Index (BMI), median (kg/m²)</td>
<td>n = 1904 (85.7)</td>
<td>22.9 (2.2)</td>
<td>28.6 (9.9)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Alcohol intake</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never, n (%)</td>
<td>n = 1597</td>
<td>n = 1658</td>
<td>n = 2054</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Recently yes, n (%)</td>
<td>n = 515</td>
<td>786 (72.3)</td>
<td>1639 (80.6)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Frequent, n (%)</td>
<td>n = 508</td>
<td>1369 (64.4)</td>
<td>163 (32.0)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Smoking status, current use of tobacco, n (%)</td>
<td>n = 1361</td>
<td>208 (15.5)</td>
<td>403 (18.7)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Systolic blood pressure mm Hg, median (mm Hg)</td>
<td>n = 2630</td>
<td>1467 (28.0)</td>
<td>130 (26.0)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Diastolic blood pressure mm Hg, median (mm Hg)</td>
<td>n = 2630</td>
<td>77 (16.0)</td>
<td>81 (16.0)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Hypertensive, n (%)</td>
<td>n = 2679</td>
<td>467 (38.0)</td>
<td>127 (24.7)</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

Data recorded as median (inter-quartile range) and frequencies (%). Smokers identified by self-report. Frequent alcohol use defined as the consumption of one or more alcoholic drinks a day/week. Hypertensive categorized as BP ≥ 140/90 mm Hg or previous diagnosis. Continuous variables were compared using the Independent Samples Mann Whitney U test; categorical variables were compared using the Chi-Square test.

3. Results

Approximately 30% of the recruited samples in both countries had data that could not be retrieved due to technical and data management issues during data collection and retrieval using the CAPI system. This loss of data was non-systematic and the sample size on which the current analysis is based is on a total samples size of n = 8145 (by sex). As such, in the sample for Ghana (41.1% (n = 1954) were male and 58.9% (n = 2799) were female, 75.2% (n = 3369) aged 50 years old and 24.8% (n = 1174) aged 18–49 years old) and for SA (32.2% (n = 1094) were male and 67.8% (n = 2298) were female, 67.5% (n = 2293) aged 50 years old and 32.5% (n = 1105) aged 18–49 years old). The characteristics of the population are presented in Table 1. Due to non-responses for some questionnaire items, the number of responses (n) for each variable is included in the tables. Significant differences were recorded between the two countries, with more older people (Ghana 75.2%; SA 67.5%; p < 0.01) and more men (Ghana 41.1%; SA 32.3%; p < 0.01) in Ghana than in SA, whereas SA had more urban residents (Ghana 41.6%; SA 72.8%), and more participants from SA had a higher educational status (Ghana 14.4%; SA 42.1%) and a higher level of hypertension prevalence (SA 44.7%; Ghana 30.9% p < 0.01)

3.1. Knowledge

Approximately one-third (31.3%; n = 2190) of all respondents were not aware that a high salt diet could cause a serious health problem. This was consistently observed among older and younger
adults, men and women across both countries (Table 2). Significant associations were recorded between respondents’ knowledge and their ethnicity within the South African cohort. Those with a "coloured" ethnic background recorded the highest knowledge (84%; p < 0.01).

### Table 2. Association between salt knowledge, attitudes and behaviours (KAB) and demographic characteristics of Ghanaians (n = 6746) and South Africans (n = 3776); younger (n = 2279) and older (n = 5860); men (n = 3048) and women (n = 5860), SAGE Wave 2.

<table>
<thead>
<tr>
<th>Age Category—Countries Combined</th>
<th>Sex—Countries Combined</th>
<th>Ghana</th>
<th>SA</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-40 Years Old n = 2279</td>
<td>60+ Years Old n = 5860</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Do you think that a high salt diet could cause a serious health problem? (Yes, %)</strong></td>
<td><strong>18-40 Years Old n = 2279</strong></td>
<td>1349</td>
<td>334</td>
<td>0.16</td>
</tr>
<tr>
<td><strong>How much salt do you think you consume? Just the right amount, %</strong></td>
<td><strong>18-40 Years Old n = 2279</strong></td>
<td>1634</td>
<td>279</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td><strong>Do you eat salt to food at the table? Always&quot; and &quot;Other&quot;, %</strong></td>
<td><strong>18-40 Years Old n = 2279</strong></td>
<td>313</td>
<td>167</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td><strong>In the food you eat at home, salt is added in cooking...? Always&quot;, and &quot;Other&quot;, %</strong></td>
<td><strong>18-40 Years Old n = 2279</strong></td>
<td>1689</td>
<td>527</td>
<td>0.03</td>
</tr>
<tr>
<td><strong>Do you add any amount on a regular basis to control your salt or sodium intake? Yes, %</strong></td>
<td><strong>18-40 Years Old n = 2279</strong></td>
<td>600</td>
<td>34</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Note: "All" represents respondents from both countries. Data was recorded in frequencies. Chi square tests were conducted.

#### 3.2. Attitudes

Three quarters (74.9%; n = 5570) of all respondents perceived that they consumed just the right amount of salt. The perception of consuming “just the right amount of salt” was more frequently observed in younger adults, men, and in Ghanaians compared to South Africans.

#### 3.3. Salt Intake Behaviours

Among all respondents, 18% (n = 984) reported that they “always” and “often” (frequently) added salt to food at the table and the majority (n = 5999, 91%) reported that they frequently added salt to food at home during cooking. Almost two-thirds (62.4%) reported that they did not take any action to control their salt intake. The response to “taking actions to control salt intake on a regular basis” significantly differed according to knowledge about salt (knowledge and health, p < 0.001). For the two countries, fifty-two percent of respondents who did not think high salt could cause health problems reported that they never took actions on regular basis to reduce salt intake. Reported frequent alcohol intake was found to relate to less desirable salt intake behaviours. While 96.7% of respondents reporting frequent alcohol intake (n = 1971) also reported always or often adding salt to food while cooking, this behaviour was significantly lower (86.1%) in teetotalers (n = 756; p < 0.01). Additionally, significantly more teetotalers (51.0%) reported regularly attempting to control their salt intake when compared with frequent drinkers (33.7%; p < 0.01). Significant associations were recorded between respondents who frequently added salt to food at the table and their ethnicity within the South African cohort. Those with African/Black ethnic background reported adding more salt to food at the table than any other group (36.5%, p < 0.01).

Younger adults more frequently added salt to food at the table, added salt to food eaten at home during cooking and did less on a regular basis to control their salt intake than did older adults (Table 2). More South Africans than Ghanaians reported that they frequently added salt at the table (SA 32.9%; Ghana 9.9%; p < 0.001) and did not take actions to control their salt intake (SA 28.8%; Ghana 42.9%).
Significantly more Ghanaians than South Africans reported frequently adding salt to food during cooking (SA 79.9%; Ghana 96.3%; p < 0.01).

Multivariate analysis adjusted for sex, age, residence, educational level and hypertension prevalence showed that South Africans were more likely than Ghanaians to add salt to food at the table (OR 4.88, CI 4.071–5.611, p < 0.001) but less likely to add salt to food at home during cooking (OR 0.16, CI 0.130–0.197, p < 0.001) or to take action to control their salt intake regularly (OR 0.44, CI 0.379–0.488, p < 0.01); (Table 3). Men and younger adults were also significantly more likely to add salt to food and less likely to control salt intake. Those living in urban areas, educated to high school level or above, or those with hypertension were significantly more likely to regularly control their salt intake.

Table 3. Associations between sociodemographic variables and salt behaviours of adults in Ghana (n = 6746) and South Africa (n = 3776)—comparing the odds ratio for sub-optimal salt behaviours, SAGE Wave 2.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Salt Frequently Added to Food at the Table</th>
<th>Salt Frequently Added to Food during Cooking</th>
<th>Takes Regular Action to Control of Salt Intake</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OR (95% CI)</td>
<td>OR (95% CI)</td>
<td>OR (95% CI)</td>
</tr>
<tr>
<td>Ghana</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SA</td>
<td>Referent</td>
<td>Referent</td>
<td>Referent</td>
</tr>
<tr>
<td>Male</td>
<td>4.88 (4.071–5.611) *</td>
<td>0.16 (0.130–0.197) *</td>
<td>0.436 (0.379–0.488) *</td>
</tr>
<tr>
<td>Female</td>
<td>Referent</td>
<td>Referent</td>
<td>Referent</td>
</tr>
<tr>
<td></td>
<td>1.40 (1.182–1.680) *</td>
<td>1.36 (1.118–1.654) *</td>
<td>0.78 (0.718–0.884) *</td>
</tr>
<tr>
<td>18–49 years old</td>
<td>Referent</td>
<td>Referent</td>
<td>Referent</td>
</tr>
<tr>
<td>50+ years old</td>
<td>0.78 (0.655–0.920) *</td>
<td>0.56 (0.450–0.711) *</td>
<td>1.23 (1.096–1.384) *</td>
</tr>
<tr>
<td>Rural</td>
<td>Referent</td>
<td>Referent</td>
<td>Referent</td>
</tr>
<tr>
<td>Urban</td>
<td>0.89 (0.762–1.041) *</td>
<td>0.90 (0.744–1.099) *</td>
<td>1.41 (1.271–1.565) *</td>
</tr>
<tr>
<td>Primary school and below</td>
<td>Referent</td>
<td>Referent</td>
<td>Referent</td>
</tr>
<tr>
<td>High school and above</td>
<td>0.87 (0.741–1.020)</td>
<td>0.86 (0.719–1.048)</td>
<td>1.12 (1.004–1.240) *</td>
</tr>
<tr>
<td>Normotensive</td>
<td>Referent</td>
<td>Referent</td>
<td>Referent</td>
</tr>
<tr>
<td>Hypertensives</td>
<td>1.11 (0.952–1.299)</td>
<td>0.88 (0.734–1.087)</td>
<td>1.48 (1.328–1.649) *</td>
</tr>
</tbody>
</table>

Note: Referent indicates reference category used for the comparison. Hypertension was categorized as BP ≥ 140/90 mmHg or previous diagnosis. Logistic regression was adjusted for sex, age category, residence, educational level and hypertension prevalence, *p < 0.05.

4. Discussion

The finding that 80% or more of adults in Ghana and SA frequently add salt to their food during cooking indicates that discretionary salt use remains high in both countries. Significant differences were observed between the two countries for various behaviours, such as a third of South Africans reported adding salt to food at the table as compared to only a tenth of Ghanaians. Significant differences were also observed between younger and older adults and between the genders. The most potentially detrimental behaviours were identified in men and younger adults. The contribution of discretionary salt intake to total salt intake cannot be under-emphasized even in societies where most salt comes from processed foods. Health promotion activities are needed to decrease individual level salt intake [7] in order to decrease salt preferences over time and thus decrease discretionary salt use [7,36,38].

Knowledge related to the adverse effects of salt on health was poor. Almost one third (n = 2190) of both Ghanaians and South Africans were not aware of the relationship between high salt intake and the possibility of a serious health problem. This could potentially explain practices of high discretionary salt use [55,59,60]. Conversely, individuals who know about the health effects of excess salt in the diet have been shown to be more likely to reduce their salt intake [49]. Knowledge of hypertension may influence both salt and self-care behaviours [61]. Our results show that responses to salt knowledge, attitudes and behaviours are significantly related as shown by other authors [36].
Our data indicates participants’ high confidence in their perceived intake of the recommended levels of salt, since three-quarters of respondents reported that they consumed “just the right amount of salt.” A limitation of this study relates to potential under-reporting of salt use, as shown in other studies [49,52,62,63] and responses to salt questions may not reflect actual intakes. Studies that measured 24 h urinary sodium excretion in addition to self-reported discretionary salt use in the same respondents revealed an underestimation in reported salt intake [33,64]. Hypertension levels were high in both samples but we did not investigate whether hypertensive individuals who were receiving treatment to control their blood pressure had also received advice on salt intake. There is a possibility of misreporting, as those who have received information on salt use may feel that they consume the recommended amount. Furthermore, there might be some lack of knowledge relative to the amount of salt recommended for daily consumption, as was the case in other studies [56]. This discrepancy between perceived and actual salt consumption has the potential to result in higher than anticipated salt intakes [65].

Our data indicates a need to intensify consumer education on salt intake awareness in both countries, including discretionary salt use. Previous research contributing to South African policy change [33] suggests that further investigation into particular food items that contribute high amounts of salt to the diet is needed in Ghana. Consistent with other studies [56], more attention should be directed towards the younger population (18–49 years old) and to men, who reported worse discretionary salt knowledge, attitudes and behaviours. Dietary salt education and awareness should also be integrated into school curricular and youth programmes, particularly as hypertension and associated morbidity and mortality typically occur at younger ages in Sub Saharan Africa (SSA) [66,67].

Our finding that Ghanaians add more salt to food at home during cooking compared with their South African counterparts may not be surprising given investment in campaigns to increase consumption of iodized salt [68-70]. Within Ghana, any action related to salt reduction for addressing NCDs appears to have been overshadowed by the strong focus on the prevention of iodine deficiencies [39–41,70]. This situation appears in contrast to WHO guidelines [14], which suggest compatibility of policies on salt reduction and salt iodisation. The guidelines advise that regular monitoring of sodium (salt) intake and iodine intake at country level is needed to adjust salt iodisation over time to ensure that individuals consume sufficient iodine while reducing overall intake of salt. If salt is sufficiently iodised, a reduction of salt intake to the recommended level of 5 g per day should still provide an adequate amount of iodine [43]. Ghana’s strong emphasis on the reduction of iodine deficiencies provides a unique and untapped opportunity for addressing discretionary salt use and behaviour change. Salt used in food processing is not included in the mandatory Universal Salt Iodisation policies in either Ghana or South Africa, although there is some evidence from South Africa that indicates up to a third of margarines, bread, and savoury snack seasonings contain iodised salt [71].

We found that South Africans were almost 5 times more likely than Ghanaians to add salt to food at the table (controlling for sex, age, location, education level and hypertension prevalence). This finding was expected, as a greater proportion of the cohort in SA lived in urban areas compared with Ghana. Urbanization is one of the key drivers for excess salt consumption [15]. Further investigation regarding the effect of acculturation on addition of salt to food is of interest. The survey was conducted prior to salt legislation being introduced in SA, therefore it will be of importance to determine how the lowering of salt in processed foods impacts on both discretionary salt behaviours and actual salt intake levels in SA in the next wave of SAGE in 2017–2018.

The present study shows that almost two-thirds of the population were not taking any action to control their salt intake, and this may be explained by the finding that a third of respondents did not have any knowledge regarding the links between high salt intake and health problems. Among the key broad strategies for salt reduction is individual responsibility and action [7], for example, limiting the consumption of salty snacks and reducing the amount of salt used in cooking. The Health Belief Model explains that perceived seriousness, perceived susceptibility, perceived benefits and perceived barriers are critical evaluations an individual undertakes prior to engaging in a health behaviour [72]. Our data suggests that strategies are required to firstly increase awareness within the Health Belief Model of
health promotion as a means of supporting behaviour change. The other broad strategy is at a systemic level—including measures like those adopted in South Africa to work with food manufacturers to lower salt levels in processed foods.

The findings of the present study were somewhat surprising because, despite the extensive public awareness campaign in SA to address population salt intake levels and influence salt related behaviour (Salt Watch) [37,73] and despite that population reporting greater salt knowledge, it was the Ghanaians who appeared to be more actively controlling their salt intake (Table 2). This highlights the point that knowledge alone is not sufficient to cause a change in behaviour. Consistent with the present study, research from Newson et al. (2013) [62] showed that almost half of survey respondents were not interested in reducing their salt intake and had no intention of making any changes to their salt consumption in the immediate future. With a large hypertension burden [24], it is likely that some South Africans may not feel empowered to make dietary changes. Additionally, cultural beliefs and practices that encourage salt consumption are also of concern. Salt use for spiritual and religious purposes is common place in SA [37] and this would need to be considered in health messages.

The finding that frequent alcohol intake was associated with less desirable salt intake behaviours has been reported by others [74]. Differences in reported alcohol intake between Ghanaian and South African study participants are similar to previous analyses of alcohol consumption from Wave 1 of SAGE which indicated that there were fewer “never” drinkers (lifetime abstainers) in Ghana than in SA, while the South African cohort had more “at risk” drinkers [75].

It is well established that reducing dietary salt to 3 g/day leads to a reduction in blood pressure in both in hypertensives and normotensives [76]. Given the current estimated prevalence of hypertension in the African region, it is imperative that salt reduction messages are included in public health campaigns alongside various strategies to support behaviour change while also modifying salt levels in commonly consumed foods. Provision of practical skills and strategies to encourage change in salt intake behaviours is key in this regard.

The present study had several strengths which included the use of large, nationally representative sample sizes in both SA and Ghana. A potential limitation relates to the oversampling of older people in keeping with the purpose of the SAGE, which may limit generalizability of the findings to the population younger than 50 in both countries. Regardless, these are relatively large representations of the 50+ population, with younger comparison groups in both countries.

5. Conclusions

This study provided important insights into salt knowledge, attitudes and behaviours (KAB) in SSA. High discretionary salt use remains common practice in the region and needs urgent attention in the face of high and rising hypertension levels. Significant differences in salt KAB were evident between the two countries which suggests the use of different strategies and approaches for combating high discretionary salt intake may be appropriate, although strategies particularly targeting men and younger adults may be beneficial for both countries. The findings suggest that SA requires investment into public health campaigns to address the practice of adding salt to foods at the table, while in Ghana a focus on changing behaviours related to the use of salt in cooking is required. Campaigns and consumer education strategies—based on the Health Belief Model—may be useful to raise awareness for salt reduction in SSA.

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Author Contributions: K.E.C. and P.K. conceived and designed the research; E.M. and L.J.W. analyzed the data; E.M., K.E.C., L.J.W., J.R., R.B. and P.K. wrote the paper.
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Appendix H - Salt and low potassium intake among adult Ghanaians: WHO-SAGE Ghana Wave 3

Salt and potassium intake among adult Ghanaians: WHO-SAGE Ghana Wave 3

Elia K. Merynau, Barbara Corso, Nadia Minicucci, Ilaria Rocco, Joanna Russell, Lisa J. Ware, Richard Biltwvim, Paul Kowal, Aliea E. Schutte and Karen E. Charrington

Abstract

Though Ghana has high hypertension prevalence, the country lacks current national salt consumption data required to build and enhance advocacy for salt reduction. We explored the characteristics of a randomly selected sub-sampal population that had valid urine collection, along with matched survey, anthropometric and BP data (n = 839, mean age = 60y), from the World Health Organization’s Study on global AGEing and adult health (WHO-SAGE), Ghana Wave 3, n = 839). We also investigated the relationship between salt intake and blood pressure (BP) among the cohort. BP was measured in triplicate and 24-hour urine was collected for the determination of urinary sodium (Na), potassium (K), creatinine (Cr) and iodine levels. Hypertension prevalence was of 44.3%. Median salt intake was 8.3 g/day, higher in women compared to men (8.6; Interquartile range (IQR) 7.5 g/day vs 7.5, IQR 7.4 g/day, p < 0.01), younger participants (< 49 y) compared to older ones (50+ y) (9.7, IQR 7.9 g/day vs 8.1, IQR 7.1 g/day, p < 0.01) and those with higher Body Mass Index (BMI) (> 30 kg/m²) compared to a healthy BMI (18.5–24.9 kg/m²) (10.0, IQR 5.1 g/day vs 6.2, IQR 5.6 g/day, p < 0.01). More than three-quarters (77%, n = 647) of participants had salt intakes above the WHO maximum recommendation of 5 g/day, and nearly two thirds (65%, n = 548) had daily K intakes below the recommended level of 90 mmol. Dietary sodium to potassium (Na:K) ratios above 2 mmol/mmol were positively associated with increasing BP with age. Population-based interventions to reduce salt intake and increase K consumption are needed.

Keywords: Hypertension, Salt intake. Potassium. 24 h urine, Ghana

Introduction

Cardiovascular diseases (CVDs) remain a major contributory factor for mortality and morbidity worldwide, accounting for 17.9 million deaths in 2016, and representing a third of all deaths globally [1]. While Low- and Middle-Income Countries (LMICs) already share the greatest impact of CVD-related deaths, with rates of 300–600 deaths per 100,000 population, these are predicted to increase, causing premature, avoidable loss of lives [2]. Hypertension is a major risk factor for CVD and accounted for more than 50% of CVD-specific deaths in 2012 [3]. It has been estimated that the burden of hypertension will increase to approximately 1.56 billion people globally by 2025, with larger populations of hypertensives living in LMICs [3–5].

Hypertension is a common condition in Ghana, where its prevalence has increased more than two-fold over just two decades (1988–2007) [6]. A recent nationally representative study among participants largely 50 years and older, in Ghana, reported the prevalence of hypertension to be 58.9% in adults with about one-fifth of those with hypertension being aware of having the condition [7]. Reducing population-level prevalence of hypertension by 30% by the year 2030 is identified by WHO as one of the nine voluntary global targets to reduce non-communicable
diseases (NCDs) [8]. Salt reduction has been identified by the WHO as one ‘best buy’ approach to reduce overall CVD risk through lowering of BP [8].

Increased consumption of salt (> 2 g Na/day, equivalent to 5 g salt/day) together with insufficient potassium (K) intake (< 3.5 g/day) are strongly associated with a number of NCDs including hypertension [10–14]. Several systematic literature reviews, meta analyses and randomized-controlled trials have shown that reduced sodium (Na) consumption results in a decline in blood pressure in both hypertensives and normotensive adults [12, 14–17], which saves lives [18]. In view of this, ‘WHO’s SHAKE the Salt Habit’ resource has emphasized the importance of measuring and monitoring population salt consumption patterns in order to inform stakeholders about strategies to reduce salt intake and evaluate the effect of any implemented salt reduction programmes [19]. Though Ghana is committed to the World Health Assembly’s target of 30% relative reduction in the population salt intake by 2025 [10], the country has made slow progress towards achieving the target due to other competing public health priorities and limited resources [20].

Few studies have been conducted to assess salt intake in the Ghanaian population [21]. A lack of recent, nationally representative data on population salt consumption among adults has further been a disincentive for advocacy around salt reduction efforts [22]. The current study was undertaken to obtain a reliable estimate of population salt intake and salt use behaviour, and to assess the relationship between salt and K intake with blood pressure (BP) in Ghanaian adults.

Methods

Study design, population and outcomes

This study is a nested sub study of WHO’s Study on global AGing and adult health (WHO - SAGE) Wave 3 Ghana, which collected 24 h urine samples for analysis of Na and K [23]. WHO - SAGE is a longitudinal cohort study conducted in six LMICs (China, Ghana, India, Russia, Mexico and South Africa) with the aim to examine the ageing process and address health inequalities among adult populations [24]. Participants were sampled based on a design used in the 2003 World Health Survey with primary sampling units (households) stratified by region and location (urban/rural). The study design randomly selects 24 households from an enumeration area (twenty 50+ year households and four 18-49 year households). In the 50+ year households, all participants are selected and compared with a smaller number of participants selected from the 18-49 year households, details of which are described elsewhere [25]. WHO SAGE Ghana Wave 3 data collection was completed over a period of 1 year (July 2018–June 2019) with n = 1100 24 h urine samples collected nationwide. Out of 5570 participants recruited for WHO - SAGE Ghana Wave 3, 1102 (20%), were randomly selected to provide urine samples (nested sub study). Of these, 76.7% (n = 844) had successful (BP) data and 88.6% (n = 976) had complete urine samples. However, fewer participants (n = 839) had a complete urine collection, accompanied with survey, anthropometric and valid BP data (Fig. 1).

Field worker teams consisted of 3–5 interviewers per team who visited participants in their homes and workplaces to conduct interviews. All field workers were trained by the local WHO SAGE team with standardized survey materials [24]. Surveys were conducted in the participants’ preferred home language with the use of the computer assisted personal interview (CAP) method.

The WHO/Pan American Health Organization (PAHO) protocol was utilised in the determination and collection of Na, K and Cr in the 24 h urine collections. In collecting urine samples, 5-l urine bottles containing 1 g thymol as preservative, were given to participants to collect 24 h urine. The collection procedure was thoroughly explained to participants. In brief it is as follows: 1) void the ‘first urine’ and note the time but include the ‘last urine’ 2) keep the bottles to yourself and collect only your own urine 3) collect all urine passed within the 24 h and 4) keep collected urine in a cool place [26].

The 24 h urine was collected, thoroughly mixed, volumes recorded, 5 aliquots of 5 ml were generated and samples kept in cold boxes and transported to the Noguchi Memorial Institute for Medical Research of the University of the Ghana (NMIMR-UG). Urine samples were considered valid if the volume was ≥300 ml [27, 28]. Additionally, iodine was assessed for analysis because Ghana had a universal iodine programme in place. Analysis were undertaken by NMIMR-UG, that followed the WHO/PAHO protocol for quantitative analysis of Na, K, Cr in urine samples [26]. Urine samples for iodine analyses were stored at −20 °C and batch analysed using the Sandell-Kolthoff method with ammonium persulphate digestion and microplate [29]. Creatinine excretion in this population was much lower than that reported for many other populations, from which Cr cut-off values have been determined to indicate completeness of 24 h urine collection [28]. Because of this, only urine volume was used to indicate whether urine samples were considered to represent completeness. This approach has been used in other multi-country studies including; the International Population Study on Macronutrients and Blood Pressure [INTERMAP] and the International Study of Sodium, Potassium, and Blood Pressure [INTERSALT] [27]. In the first enumerator areas (EAs) sampled within the Accra region, some calculated salt values were unfeasibly high (> 40 g/d, n = 40) due to unacceptable storage conditions [30]. A follow-up validation study...
conducted in n = 67 participants included the collection of repeated 24 h urine samples from the same participants in one EA (Alajo; n = 19), while an additional two non-urine EAs from the larger survey sample were visited as a comparator (Mataheko; n = 24 and Nima; n = 24). A second laboratory (Liberty Medical Laboratory, Accra) also performed duplicate analyses in the validation study. Values for Dosise EA (n = 23) were excluded after the validation study because they were confirmed as being unfeasible, and the validation study values replaced original measures for the case of Alajo (n = 16; 3 barcodes of urine samples in validation study were excluded because they could not be matched with those of the original study) (Supplementary Table 1).

Sodium (mmol/l) in the 24 h urine sample was converted to salt (g/d) using the formula: Na mmol/l × 24 h volume (litres) × 23.1 (molecular weight of Na)/390 (390 mg Na per 1 g NaCl (salt)). From this variable, participants were categorised as having low (<5 g/day), medium (5–9 g/day) or high (>9 g/day) salt intake. K (mmol/l) in the 24 h urine sample was converted to K (mmol/d) using the formula: K (mmol/l) × 24 h volume (litres) [31]. The ratio Na (mmol/l) to K (mmol/l) was created (Na/K) and categorised as low (<2), medium (2–5) or high (>5). BP was measured by field workers with wrist worn BP devices with positional sensors (Omron R3, Japan) [32] that have been validated by the European Society of Hypertension International Protocol [32–34]. After being seated with legs uncrossed for 5 min, three BP
readings were taken on the left wrist (1 min between each measurement) while the wrist was placed precisely at the level of heart. The last two readings were averaged as a measure of the participant's BP. Hypertension classification was based on the European Society for Hypertension Guidelines (2018) which defines hypertension as systolic ≥140 and/or diastolic ≥90 mmHg [35]. BP readings in the database were determined valid if: Systolic (SBP) > Diastolic (DBP); and SBP was between 80 and 270 mmHg; and DBP was between 40 and 180 mmHg; and SBP minus DBP (Pulse Pressure, PP) > 13 mmHg. Mean Arterial Pressure (MAP) is the average arterial pressure throughout one cardiac cycle, systolic, and diastolic. MAP was calculated using the formula: MAP = SBP + 2 (DBP)/3 [36]. Hypertension status was measured as self-reported treatment or having a measured BP ≥140/90 mmHg. Hypertension awareness was based on self-reported previous diagnosis of hypertension in those with BP ≥140/90 mmHg. Treatment was determined from self-reported medication use for hypertension within the last 2 weeks. Hypertension control was determined by self-reported medication use within the last 2 weeks and a measured BP less than 140/90 mmHg. Individuals with no current medication use and a measured BP < 140/90 mmHg were categorized as non-hypertensive.

Weight was measured with calibrated scales, while height was measured with a portable stadiometer. Data were also collected on health indicators such as tobacco, alcohol use, salt use behaviours and previous disease conditions. Physical activity levels were measured using the Global Physical Activity Questionnaire [37]. For salt use behaviour questions, responses such as ‘always’ and ‘often’ were combined to represent ‘frequent use’, whilst ‘sometimes’ and ‘rarely’ were combined to represent ‘infrequent use’.

Prior to taking part in the study, study measures were explained to participants in their home languages and written informed consent was obtained. The study complied with the Declaration of Helsinki with ethical approval from the WHO Ethics Committee (BDC 149) and the University of Ghana Medical School Ethics and Protocol Review Committee (MS-ET/M.03 - P.3.1/2005–2006).

Statistical analysis
Data were analysed using Stata Statistical Software: Release 15 (Stata Corp LLC; 2017; College Station, USA). Data distribution was checked visually and with the Shapiro-Wilk test for normality. Descriptive statistics of frequencies, percentages and median (interquartile range, IQR) were used to describe participants’ characteristics. Categorical variables were evaluated using frequencies, Pearson’s Chi-Square and Fisher’s Exact tests. Comparison between groups for non-parametric data was examined using Mann-Whitney U and Kruskal-Wallis tests and Spearman’s Rho was used to test for correlations. Linear regressions were used to evaluate the associations between variables. To test regression slopes for equality between the three salt level groups and between the three NaK ratio groups, the interaction terms of groups with age was added into the models. To test if a difference in the group’s coefficients (i.e. slope) was present, the F test was applied. If significant, post-estimation was pursued to identify which group differed from the others.

Results
Table 1 compares sociodemographic characteristics of the nested sub study sample with those included in the total Wave 3 survey collection.

Hypertension prevalence in the nested sub study was 44.3% (n = 370) with 41.4 and 46.1% for men and women respectively. Of those with hypertension, 59.7% were aware of their condition (n = 222) of which 69.1% (n = 154) were receiving prescribed antihypertensive medication. Of those being treated for hypertension, 51% (n = 77) had controlled BP (ie BP ≤140/90).

Among participants with both urine, survey data and BP data (n = 839), median intake of salt was equivalent to 8.3 g/day (IQR 7.5) (mean = 10.2 ± 7.2). Salt intake was higher in: (1) women compared to men; median 8.6 (7.5)g/day vs 7.5 (7.4)g/day, p < 0.01; (2) younger participants (18–49 years) compared to older ones (50+ years); median 9.7 (7.9)g/day vs 8.1 (7.1)g/day, p < 0.01; and (3) those with higher BMI (> 30 kg/m²) compared to a desirable BMI (18.5–24.9 kg/m²); median 10.04 (5.1)g/day vs 6.2 (5.6)g/day, p < 0.01. There was no significant difference in salt consumption between rural and urban dwellers. Overall, 77.7% (n = 657) of participants had salt intakes above the WHO maximum recommendation of 5 g/d, with 38.9% consuming more than twice this level (> 10 g/d, n = 321) and 16.3% consuming more than three times the recommended level (> 15 g/d, n = 157). More men than women (27.1% (n = 73) vs 19.9% (n = 122); p = 0.02) and older participants than younger ones (24.8% (n = 166) vs 12.1% (n = 21); p < 0.01) achieved the WHO’ salt recommendation of ≤5 g salt/day (Supplementary Tables 2 and 3).

According to groupings by salt intake (low, ≤5 g/d; medium, 5–9 g/d; high, > 9 g/d), those with higher salt intakes were significantly younger, had higher BMI, a higher urinary K excretion, a higher urinary Na:K and lower urinary iodine concentrations. However, BP and hypertension status did not differ between the groups (Table 2).

In response to the salt behaviour questions (Supplementary Table 4), 12.8% (n = 107) of participants reported that they frequently (always and often) added salt to food at the table with significantly greater numbers of younger (27.3%, n = 28,
Table 1: Demographic profile of SAGE GHA W3 survey participants and subsample with valid urine data (urine data considered valid if volume ≥ 300 ml).

<table>
<thead>
<tr>
<th></th>
<th>Main SAGE cohort (n = 3053)</th>
<th>Sub sample (n = 839)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Years</td>
<td>60 (19)</td>
<td>60 (19)</td>
<td>0.3794</td>
</tr>
<tr>
<td>18-49 years, n (%)</td>
<td>717 (23.5)</td>
<td>174 (20.7)</td>
<td>0.0190</td>
</tr>
<tr>
<td>≥50 plus years, n (%)</td>
<td>2136 (76.5)</td>
<td>665 (79.3)</td>
<td>0.4484</td>
</tr>
<tr>
<td>Sex, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>1183 (38.8)</td>
<td>371 (23.3)</td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>1870 (61.2)</td>
<td>568 (76.7)</td>
<td></td>
</tr>
<tr>
<td>Ethnicity, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Akan</td>
<td>1544 (50.6)</td>
<td>467 (59.2)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Ewe</td>
<td>216 (7.1)</td>
<td>59 (6.9)</td>
<td></td>
</tr>
<tr>
<td>Ga-Adangbe</td>
<td>234 (7.7)</td>
<td>45 (5.4)</td>
<td></td>
</tr>
<tr>
<td>Gaamu</td>
<td>38 (1.3)</td>
<td>6 (0.7)</td>
<td></td>
</tr>
<tr>
<td>Ghul</td>
<td>76 (2.5)</td>
<td>12 (1.4)</td>
<td></td>
</tr>
<tr>
<td>Gain</td>
<td>38 (1.3)</td>
<td>16 (1.9)</td>
<td></td>
</tr>
<tr>
<td>Mandé-Busua Gea</td>
<td>61 (2.1)</td>
<td>3 (0.4)</td>
<td></td>
</tr>
<tr>
<td>Mole-Ochoboe</td>
<td>174 (5.7)</td>
<td>24 (2.9)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>612 (20.0)</td>
<td>174 (20.7)</td>
<td></td>
</tr>
<tr>
<td>Residence, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>1301 (42.6)</td>
<td>457 (54.5)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Rural</td>
<td>1752 (57.4)</td>
<td>392 (45.5)</td>
<td></td>
</tr>
<tr>
<td>Marital status, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never married</td>
<td>208 (6.8)</td>
<td>39 (4.6)</td>
<td>0.002</td>
</tr>
<tr>
<td>Married/cohabiting</td>
<td>1769 (57.7)</td>
<td>470 (56.0)</td>
<td></td>
</tr>
<tr>
<td>Separated/divorced</td>
<td>369 (12.1)</td>
<td>87 (10.4)</td>
<td></td>
</tr>
<tr>
<td>Widowed</td>
<td>715 (23.4)</td>
<td>243 (28.2)</td>
<td></td>
</tr>
<tr>
<td>Never been to school, n (%)</td>
<td>1119 (36.7)</td>
<td>240 (28.0)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Education (years)</td>
<td>10 (3)</td>
<td>10 (3)</td>
<td>0.0139</td>
</tr>
<tr>
<td>BMI kg/m²</td>
<td>24.2 (6.8)</td>
<td>25.4 (7.4)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Waist to height ratio</td>
<td>0.44 (0.11)</td>
<td>0.46 (0.13)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Never used alcohol, n (%)</td>
<td>1665 (54.9)</td>
<td>483 (57.6)</td>
<td>0.052</td>
</tr>
<tr>
<td>Never used tobacco, n (%)</td>
<td>2739 (90.0)</td>
<td>759 (89.5)</td>
<td>0.68</td>
</tr>
<tr>
<td>Systolic BP (mm Hg)</td>
<td>124 (26.5)</td>
<td>126 (29.0)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Diastolic BP (mm Hg)</td>
<td>76 (17.1)</td>
<td>76 (17.1)</td>
<td>0.83</td>
</tr>
<tr>
<td>Mean Arterial Pressure (MAP)</td>
<td>92.5 (15.2)</td>
<td>92.3 (14.7)</td>
<td>0.24</td>
</tr>
<tr>
<td>Hypertension, n (%)</td>
<td>1152 (37.4)</td>
<td>370 (44.3)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Diabetes, n (%)</td>
<td>157 (5.2)</td>
<td>67 (8.0)</td>
<td>0.01</td>
</tr>
<tr>
<td>Portion of fruit, n (%)</td>
<td></td>
<td></td>
<td>0.005</td>
</tr>
<tr>
<td>Met WHO5 recommendation of at least 5 servings of fruits and vegetables</td>
<td>1591 (57.4)</td>
<td>442 (54.5)</td>
<td>0.14</td>
</tr>
<tr>
<td>Frequently add salt to food at table, n (%)</td>
<td>642 (21.1)</td>
<td>107 (12.7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Frequently add salt to food during cooking, n (%)</td>
<td>257 (8.5)</td>
<td>67 (8.1)</td>
<td>0.05</td>
</tr>
<tr>
<td>Believe they consume too much salt, n (%)</td>
<td>265 (8.8)</td>
<td>92 (11.0)</td>
<td>0.05</td>
</tr>
<tr>
<td>Believe a high salt diet is bad for health, n (%)</td>
<td>2241 (75.5)</td>
<td>651 (80.0)</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Note: subsample: all respondents with CAPI data and valid urine; sex and age recorded. Some variables may contain missing data. Data are presented as median (IQR) unless otherwise indicated. Hypertension by measured BP ≥ 140 and/or 90 mmHg or previous diagnosis self-reported. Ethnicity, marital status, education, alcohol/tobacco use and diabetes prevalence by self-report. Mann Whitney Test used to compare medians. Pearson Chi-Square test and Fisher’s Exact Test used to compare proportions.
Table 2 Nested cohort by salt excretion levels, low, medium and high salt groups, WHO – SAGE Ghana Wave 3 (2019)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Low salt &lt; 5 g/d (n = 186)</th>
<th>Medium salt 5-9 g/d (n = 269)</th>
<th>High salt &gt; 9 g/d (n = 378)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, yr</td>
<td>64 (28)</td>
<td>60 (17)</td>
<td>58 (18)</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Sex, male, n (%)</td>
<td>n = 185</td>
<td>n = 269</td>
<td>n = 378</td>
<td>0.02</td>
</tr>
<tr>
<td>Ethnicity n (%)</td>
<td>n = 184</td>
<td>n = 268</td>
<td>n = 376</td>
<td>0.03</td>
</tr>
<tr>
<td>Akan</td>
<td>122 (66.3)</td>
<td>168 (62.7)</td>
<td>203 (54.0)</td>
<td></td>
</tr>
<tr>
<td>Ga</td>
<td>7 (3.8)</td>
<td>11 (4.1)</td>
<td>27 (7.2)</td>
<td></td>
</tr>
<tr>
<td>Ewe</td>
<td>14 (7.6)</td>
<td>18 (6.7)</td>
<td>24 (6.4)</td>
<td></td>
</tr>
<tr>
<td>Male-Edgabon</td>
<td>5 (2.7)</td>
<td>6 (2.2)</td>
<td>13 (3.5)</td>
<td></td>
</tr>
<tr>
<td>Male-Buengela</td>
<td>1 (0.5)</td>
<td>1 (0.3)</td>
<td>2 (0.5)</td>
<td></td>
</tr>
<tr>
<td>Gaasi</td>
<td>3 (1.6)</td>
<td>3 (1.1)</td>
<td>6 (1.4)</td>
<td></td>
</tr>
<tr>
<td>Guan</td>
<td>0 (0.0)</td>
<td>11 (4.1)</td>
<td>1 (0.3)</td>
<td></td>
</tr>
<tr>
<td>Gruma</td>
<td>1 (0.5)</td>
<td>1 (0.3)</td>
<td>2 (0.5)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>31 (16.8)</td>
<td>48 (17.8)</td>
<td>94 (25.0)</td>
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</tr>
<tr>
<td>Urban n (%)</td>
<td>n = 185</td>
<td>n = 269</td>
<td>n = 378</td>
<td>0.79</td>
</tr>
<tr>
<td>Education (years)</td>
<td>n = 118</td>
<td>n = 179</td>
<td>n = 250</td>
<td>0.07</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>n = 179</td>
<td>n = 258</td>
<td>n = 356</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Salt intake, g/d</td>
<td>n = 186</td>
<td>n = 269</td>
<td>n = 371</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>K intake, mmol/d</td>
<td>n = 186</td>
<td>n = 269</td>
<td>n = 378</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>NO-K</td>
<td>n = 186</td>
<td>n = 269</td>
<td>n = 378</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Urinary sodium excretion, mmol/day</td>
<td>n = 150</td>
<td>n = 211</td>
<td>n = 292</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Systolic BP, mmHg</td>
<td>n = 196</td>
<td>n = 266</td>
<td>n = 375</td>
<td>0.73</td>
</tr>
<tr>
<td>Diastolic BP, mmHg</td>
<td>n = 188</td>
<td>n = 270</td>
<td>n = 379</td>
<td>0.08</td>
</tr>
<tr>
<td>Pulse pressure, mmHg</td>
<td>n = 186</td>
<td>n = 266</td>
<td>n = 375</td>
<td>0.20</td>
</tr>
<tr>
<td>Mean Arterial Pressure (MAP), mmHg</td>
<td>n = 185</td>
<td>n = 266</td>
<td>n = 378</td>
<td>0.85</td>
</tr>
<tr>
<td>Hypertension Prevalence, n (%)</td>
<td>n = 186</td>
<td>n = 268</td>
<td>n = 378</td>
<td>0.13</td>
</tr>
<tr>
<td>Hypertension awareness, n (% of hypertension prevalence)</td>
<td>n = 94</td>
<td>n = 110</td>
<td>n = 166</td>
<td>0.16</td>
</tr>
<tr>
<td>Hypertension medication, current use n (% of hypertension awareness)</td>
<td>n = 51</td>
<td>n = 62</td>
<td>n = 108</td>
<td>0.23</td>
</tr>
<tr>
<td>Hypertension control, n (% of Hypertension medication)</td>
<td>n = 31</td>
<td>n = 47</td>
<td>n = 74</td>
<td>0.82</td>
</tr>
<tr>
<td>Smoking, n (%)</td>
<td>n = 105</td>
<td>n = 269</td>
<td>n = 378</td>
<td>0.44</td>
</tr>
<tr>
<td>Alcohol use, n (%)</td>
<td>n = 182</td>
<td>n = 269</td>
<td>n = 378</td>
<td>0.82</td>
</tr>
</tbody>
</table>

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Table 2 Nested cohort by salt excretion levels, low, medium and high salt groups, WHO – SAGE Ghana Wave 3 (2019) (Continued)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Low salt ≤ 5 g/d (n = 186)</th>
<th>Medium salt 5-9 g/d (n = 269)</th>
<th>High salt &gt; 9 g/d (n = 378)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruits and legs, met recommendation n (%)</td>
<td>80 (44.0)</td>
<td>115 (42.8)</td>
<td>156 (41.3)</td>
<td>0.38</td>
</tr>
<tr>
<td>n = 186</td>
<td>n = 269</td>
<td>n = 378</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequently adds salt to food at the table, n (%)</td>
<td>97 (52.2)</td>
<td>152 (56.5)</td>
<td>193 (51.1)</td>
<td>0.65</td>
</tr>
<tr>
<td>n = 186</td>
<td>n = 269</td>
<td>n = 378</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequently adds salt to cooking at home, n (%)</td>
<td>24 (13)</td>
<td>35 (13)</td>
<td>2 (2.0)</td>
<td>0.48</td>
</tr>
<tr>
<td>n = 185</td>
<td>n = 206</td>
<td>n = 378</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Believe that they are eating just the right amount of salt n (%)</td>
<td>149 (80.5)</td>
<td>144 (80.3)</td>
<td>144 (80.3)</td>
<td>0.97</td>
</tr>
<tr>
<td>n = 185</td>
<td>n = 206</td>
<td>n = 378</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Believe a high salt diet can cause a serious health problem, n (%)</td>
<td>105 (55.8)</td>
<td>169 (63.3)</td>
<td>228 (60.6)</td>
<td>0.18</td>
</tr>
<tr>
<td>n = 185</td>
<td>n = 206</td>
<td>n = 378</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does something to control salt consumption, n (%)</td>
<td>102 (54.8)</td>
<td>126 (48.5)</td>
<td>182 (50.1)</td>
<td>0.50</td>
</tr>
<tr>
<td>n = 185</td>
<td>n = 206</td>
<td>n = 378</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Data are presented as median [IQR, interquartile range] unless otherwise stated. BMI, body mass index; height, body mass index; tobacco use by self-report; alcohol use by self-report; met fruits and vegetables recommendation indicates consumed five or more servings of fruits and vegetables a day; salt behaviour responses, frequency indicates always and often; continuous variables compared using Independent Kruskal-Wallis Test and categorical variables compared using Pearson Chi-Square Test and Fisher’s Exact Test. a, b, c sig at p < 0.05

$p = 0.02$ and rural (61%, n = 61, <0.01) dwellers responding affirmatively to this question. More than three quarters (80.1%, n = 671) of the surveyed population reported that they frequently added salt to food at home during cooking while 60.9% (n = 508) perceived themselves to consume the right amount of salt. While 93.9% (n = 126) did not know that a high salt diet could cause a serious health problem. 48.5% (n = 394) of the participants reported actively doing something on a regular basis to control their salt intake. Of those who knew a high salt diet could cause a serious health problem, 56.0% (n = 378) did something on a regular basis to control their salt intake.

Almost two-thirds (65%, n = 548) of participants did not meet the daily K recommendation of ≥90 mmol [38], with those in the lowest salt intake group having the lowest urinary concentrations. While 42.6% (n = 141) of urban participants met the guidelines for K intake, this was the case for only 28.6% (n = 101) of participants residing in rural areas (p < 0.01). Only 7.6% (n = 63) achieved the recommended Na: K ratio of ≤1 mmol [38].

There was a strong positive correlation between 24h urinary Na and K concentrations (Spearman’s rho = 0.71, p < 0.01). Linear regression indicated that urinary Na excretion accounted for more than half the variability in urinary K excretion (R² = 0.51, F (1, 833) = 861, p < 0.01). Urinary K excretion increased by 0.71 mmol/day for each mmol/day increase in urinary Na such that Na: K ratio was significantly higher in the high salt group compared to the low salt group (median 2.3 [1.9]g/day vs 1.7 [1.9]g/day, respectively, p < 0.01).

The high Na: K group had a significantly higher BMI than those in the lowest Na: K group (median 28.1, IQR 8.2 vs 24.8, IQR 7.0, p = 0.01) and had higher number of participants who reported doing something on regular basis to control their salt intake than those in the lowest Na: K group (61.5%, n = 15 vs 42.7%, n = 166, p < 0.01) (Table 3).

Excluding all participants on treatment for hypertension (n = 154), a Spearman’s rank order correlation showed no association between Na excretion, K excretion or Na: K ratio and SBP, DBP or PP. We also found no significant difference between the regression slopes of SBP, DBP or PP with age in low (<5 g/d, n = 154), medium (5-9 g/d, n = 220) and high (>9 g/d, n = 302) salt groups (Fig. 2). However, there was an association between BP and the age regression slope according to urinary Na: K ratio. Compared with low Na: K ratio (<2) and medium Na: K (2–5) ratios, the high Na: K group (>5) had a significantly steeper slope with age for both SBP and DBP (p = 0.01 and p < 0.01 respectively). No significant differences for the slopes in all three Na: K groups was found for PP (Fig. 3). Among the high salt group (>9 g/d), univariate analysis showed a significant relationship between age, father’s education, diabetes, K and physical activity with SBP while sex, age and father’s education were associated with DBP.

**Discussion**

In a nationally representative sample of adult Ghanaians (50 years and older), we report that 24 h urinary Na excretion equated to a median salt intake of 8.3 g/day, with more than three-quarters of participants having salt intakes in excess of the WHO recommendation of <5 g/day. This is considerably higher than median salt consumption values of 6.8 g and 7.2 g/day reported by recent studies from South Africa [31, 39], a country that has adopted
Table 3 Nested cohort by urinary sodium to potassium (Na/K) ratio, low, medium and high groups, WHO – SAGE Ghana Wave 3 (2019)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Low Na/K (≤ 2)</th>
<th>Medium Na/K (2-5)</th>
<th>High Na/K (&gt; 5)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (yrs)</strong></td>
<td>60 (18)</td>
<td>61 (19)</td>
<td>58 (22)</td>
<td>0.44</td>
</tr>
<tr>
<td><strong>Sex male, n (%)</strong></td>
<td>n = 336</td>
<td>n = 389</td>
<td>n = 41</td>
<td>0.20</td>
</tr>
<tr>
<td><strong>Etiology, n (%)</strong></td>
<td>n = 337</td>
<td>n = 387</td>
<td>n = 41</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td><strong>Ank</strong></td>
<td>229 (37.7)</td>
<td>246 (63.6)</td>
<td>17 (41.5)</td>
<td></td>
</tr>
<tr>
<td><strong>Ga</strong></td>
<td>5 (1.3)</td>
<td>29 (7.5)</td>
<td>10 (24.4)</td>
<td></td>
</tr>
<tr>
<td><strong>Ewe</strong></td>
<td>31 (7.8)</td>
<td>23 (5.9)</td>
<td>1 (2.4)</td>
<td></td>
</tr>
<tr>
<td><strong>Mole-dagbon</strong></td>
<td>13 (3.3)</td>
<td>11 (2.8)</td>
<td>0 (0.0)</td>
<td></td>
</tr>
<tr>
<td><strong>Mole-busanga</strong></td>
<td>2 (0.5)</td>
<td>1 (0.3)</td>
<td>0 (0.0)</td>
<td></td>
</tr>
<tr>
<td><strong>Gruka</strong></td>
<td>7 (1.9)</td>
<td>5 (1.3)</td>
<td>0 (0.0)</td>
<td></td>
</tr>
<tr>
<td><strong>Guar</strong></td>
<td>12 (3.0)</td>
<td>4 (1.0)</td>
<td>0 (0.0)</td>
<td></td>
</tr>
<tr>
<td><strong>Grunia</strong></td>
<td>3 (0.8)</td>
<td>3 (0.8)</td>
<td>0 (0.0)</td>
<td></td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td>91 (23.9)</td>
<td>65 (16.8)</td>
<td>173 (21.2)</td>
<td></td>
</tr>
<tr>
<td><strong>Urban n (%)</strong></td>
<td>n = 338</td>
<td>n = 389</td>
<td>n = 41</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td><strong>Education (years)</strong></td>
<td>n = 253</td>
<td>n = 267</td>
<td>n = 26</td>
<td>0.51</td>
</tr>
<tr>
<td><strong>BMI kg/m²</strong></td>
<td>n = 337</td>
<td>n = 364</td>
<td>n = 19</td>
<td>0.04</td>
</tr>
<tr>
<td><strong>Salt intake g/d</strong></td>
<td>n = 338</td>
<td>n = 384</td>
<td>n = 40</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td><strong>K intake, mmol/d</strong></td>
<td>75 (74.6)</td>
<td>86 (66.8)</td>
<td>139 (119.8)</td>
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</tr>
<tr>
<td><strong>N 24</strong></td>
<td>9.04 (4.93)</td>
<td>4.95 (3.87)</td>
<td>5.82 (3.83)</td>
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</tr>
<tr>
<td><strong>Urine volume excretor, mmol/day:</strong></td>
<td>n = 338</td>
<td>n = 388</td>
<td>n = 40</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td><strong>Systolic BP, mmHg</strong></td>
<td>n = 336</td>
<td>n = 385</td>
<td>n = 40</td>
<td>0.03</td>
</tr>
<tr>
<td><strong>Diastolic BP, mmHg</strong></td>
<td>126 (26)</td>
<td>126 (22)</td>
<td>125 (30)</td>
<td></td>
</tr>
<tr>
<td><strong>Pulse pressure, mmHg</strong></td>
<td>77 (17.0)</td>
<td>75 (15.0)</td>
<td>77 (15.0)</td>
<td></td>
</tr>
<tr>
<td><strong>Pulse pressure, mmHg</strong></td>
<td>n = 338</td>
<td>n = 383</td>
<td>n = 40</td>
<td>0.26</td>
</tr>
<tr>
<td><strong>Mean Arterial Pressure (MAP), mmHg</strong></td>
<td>n = 336</td>
<td>n = 387</td>
<td>n = 40</td>
<td>0.15</td>
</tr>
<tr>
<td><strong>Hypertension prevalence, n (%)</strong></td>
<td>n = 336</td>
<td>n = 387</td>
<td>n = 40</td>
<td>0.05</td>
</tr>
<tr>
<td><strong>Hypertension awareness, n (%)</strong></td>
<td>n = 336</td>
<td>n = 387</td>
<td>n = 40</td>
<td>0.05</td>
</tr>
<tr>
<td><strong>Stroke, n (%)</strong></td>
<td>n = 339</td>
<td>n = 389</td>
<td>n = 41</td>
<td>0.05</td>
</tr>
<tr>
<td><strong>Diabetes, n (%)</strong></td>
<td>n = 336</td>
<td>n = 389</td>
<td>n = 41</td>
<td>0.05</td>
</tr>
<tr>
<td><strong>Tobacco use, n (%)</strong></td>
<td>n = 339</td>
<td>n = 389</td>
<td>n = 41</td>
<td>0.05</td>
</tr>
<tr>
<td><strong>Alcohol use, n (%)</strong></td>
<td>n = 339</td>
<td>n = 389</td>
<td>n = 41</td>
<td>0.05</td>
</tr>
</tbody>
</table>
Table 3 Nested cohort by urinary sodium to potassium (Na/K) ratio, low, medium and high groups, WHO – SAGE Ghana Wave 3 (2019)
(Continued)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Low Na: K &lt; 2</th>
<th>Medium Na: K 2-5</th>
<th>High Na: K &gt; 5</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruits and Veg, met recommendation n (%)</td>
<td>n = 395</td>
<td>n = 289</td>
<td>n = 41</td>
<td>0.74</td>
</tr>
<tr>
<td></td>
<td>212 (53.1)</td>
<td>203 (52.2)</td>
<td>24 (58.5)</td>
<td></td>
</tr>
<tr>
<td>Frequently add salt to food at the table, n (%)</td>
<td>n = 330</td>
<td>n = 389</td>
<td>n = 41</td>
<td>0.88</td>
</tr>
<tr>
<td></td>
<td>52 (15.6)</td>
<td>48 (12.3)</td>
<td>6 (14.6)</td>
<td></td>
</tr>
<tr>
<td>Frequently add salt to cooking at home, n (%)</td>
<td>n = 339</td>
<td>n = 289</td>
<td>n = 41</td>
<td>0.30</td>
</tr>
<tr>
<td></td>
<td>320 (80.2)</td>
<td>311 (79.0)</td>
<td>33 (80.5)</td>
<td></td>
</tr>
<tr>
<td>Believes they are eating just the right amount of salt n (%)</td>
<td>n = 337</td>
<td>n = 287</td>
<td>n = 41</td>
<td>0.48</td>
</tr>
<tr>
<td></td>
<td>247 (62.2)</td>
<td>231 (59.7)</td>
<td>24 (58.5)</td>
<td></td>
</tr>
<tr>
<td>Believes high salt diet can cause a serious health problem, n (%)</td>
<td>n = 383</td>
<td>n = 375</td>
<td>n = 40</td>
<td>0.18</td>
</tr>
<tr>
<td></td>
<td>304 (78.5)</td>
<td>311 (82.1)</td>
<td>30 (75.0)</td>
<td></td>
</tr>
<tr>
<td>Does something to control salt consumption, n (%)</td>
<td>n = 380</td>
<td>n = 375</td>
<td>n = 38</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td></td>
<td>166 (42.7)</td>
<td>209 (55.7)</td>
<td>15 (38.5)</td>
<td></td>
</tr>
</tbody>
</table>

Data are presented as median (IQR, interquartile range) unless otherwise stated. BMI: body mass index; BP: blood pressure; IQR: interquartile range; OCP: oral contraceptive pill; OR: odds ratio; poly: polytomous; SES: socio-economic status; TM: tobacco use by self-report; TV: tobacco use by self-report; W: women; WHO: World Health Organization

Fig. 2 Slope of systolic, diastolic, pulse pressure and MAP with age in low (< 5 g/day, n = 154), medium (5-9 g/day, n = 220) and high (> 9 g/day, n = 302) salt groups including those on BP medication.
mandatory salt reduction policies. Surprisingly, salt intake in the current study was higher in women than men, which is in contrast to findings of other studies [40, 41], and warranting further investigation.

Our data provides much-needed information required to inform strategies to meet the WHO global voluntary target for NCD prevention of 30% reduction in mean population intake of salt, with the aim of achieving a target of less than 5 g per day by 2025 [8]. The only other available information on 24 h urinary Na excretion in Ghana was collected over a decade ago when salt intake was estimated to be 6.9 g/day [42]. Over this time, the Ghanaian food environment has changed dramatically [43, 44] with the emergence of energy dense, nutrient poor, processed convenience foods such as instant noodles, salty snacks (eg, potato, corn, and tortilla chips), visible fat (eg, butter, margarine, oils, dressings and gravies), ready-made baked foods (eg, cookies, cakes, pies and pastries), desserts such as puddings and cheesecake, and sweetened products (eg, sugar, syrup, ice cream, candy, and carbonated and noncarbonated sweetened drinks). Additionally, frequent consumption of highly salted foods, such as fish and meat, remains part of the traditional Ghanaian cuisine, and salt use in cooking remains high [42, 45].

It is noteworthy that more than three quarters of participants in the current study reported adding salt to food during cooking. Poor salt use behavior is widespread in the Ghanaian population; a previous study involving 12 villages in Ghana in 2006 reported that 98% of participants added salt to food during cooking, while about half (52%) added salt to food at the table [21]. In comparison to South Africans, Ghanaians reported adding salt to food during cooking more frequently [45], presumably because mass media public health campaigns to lower salt use, such as Salt Watch in South Africa have not yet occurred in Ghana [46]. Further, Ghana’s national salt iodization programme, along with accompanying major public health campaigns on iodine consumption [47–50] may partially be responsible for an increase in discretionary salt intake. However, lack of information on sources of salt provided from discretionary and non-discretionary
sources, as in processed foods, prevents further hypothesis in this regard.

Despite the current study not including a dietary assessment component, a recent systematic review of dietary sources of salt in LMICs identified that bread, meat and meat products, bakery products, instant noodles, salted preserved foods, milk and dairy products, and condiments were major sources thereof [51]. In some LMICs, bread alone may contain as much as 1.36 g salt per 100 g bread [52]. For many African countries, bread has become a staple food, such as in some regions of Democratic Republic of Congo, where bread has replaced cassava [53]. The nutrition transition taking place in Sub-Saharan Africa and its transformation of dietary patterns from a reliance on traditional staples to an increased intake of energy dense, nutrient poor foods (and often Na rich) foods may partly be responsible for the observed high salt intake reported by this study. In support of this, the Ghana Demographic and Health Survey 2014 reported that more than a third (36%) of participants consumed salted dried fish [54], while in the Ghana National Iodine Survey Report 2015, consumption of boiled rice, cereals was frequent and widespread with nearly half (48.8%) of the participants having consumed this item at least 6 times a week [55].

Awareness of excessive salt intake was low in the current study. Sixty one percent of participants believed that they were meeting the salt recommendation guidelines, but only 22.3% actually achieved this. Estimations of dietary salt intake using dietary recall methods usually indicates a reduced daily intake compared to 24 h urinary collections [56–58]. The tendency to underestimate salt consumption is high as many people are unaware of the recommendation for salt consumption, unable to determine the salt content of everyday foods such as bread and cereals, or that of composite meals [59–61]. In Ghana, there are no salt reduction strategies in place such as: mandatory or voluntary levels of salt permitted in processed foods; regulations for food labelling to indicate salt content in products, or front-of-pack signposting for high salt warnings. In addition, the Ghanaian food composition tables are outdated and incomplete in the case of Na [62], making it difficult to assess food contributions to total salt intake. In view of this, regular monitoring and evaluation of the food environment and food consumption patterns are warranted.

Potassium excretion, although low (median 63.8 mmol/day, IQR 74.8, with 65% not meeting the recommended daily intake of K), was higher than that reported by other studies in the region [31, 39]. The K content of the food items obtained from the 2010–2011 Ghana Food Balance Sheet indicates that K supply per capita per day was about 9086 mg/day (233 mmol/day), approximately 2.6-fold larger than the WHO recommended level (≥ 90 mmol/day) with yams, cassava and plantains constituting the bulk of K supply [63, 64]. However, food balance sheets represent apparent, rather than actual food consumption, and thereby provide an overestimation of intake.

Hypertension prevalence in the current study was high (50 + y, 52.6%; 18–48y, 14.5%), with less than two thirds (60%) of participants classified as hypertensives being aware of the condition (i.e. diagnosed), of which 69.1% were being treated with antihypertensive medication, half of which had BP levels considered to be controlled (<140/90 mmHg). Surprisingly, we found no association between urinary Na, K or NK ratio with BP in contrast to findings from other comparable studies [65–67] but in agreement with others [31, 68]. A possible reason may be the day to day variability in salt intake, which results in a high intra-individual variability in urinary Na excretion. Though 24 h Na excretion is considered to be the gold standard method for determination of population Na intake, repeated 24 h collections over periods provide more accurate estimating an individual’s habitual salt intake [69, 70]. However, this approach is typically impractical for large population studies such as the one reported here. Similarly, no difference was found between the slopes of SBP, DBP or PP with age according to three categories of salt intake, namely low (<5 g/day), medium (5–9 g/day) and high (>9 g/day). However, high and medium urinary Na: K had steeper slopes of BP with age as compared with those in the low Na: K category. A national survey (WHO SAGE Wave 2 South Africa) conducted in 2015 reported similar findings [31]. This association was first explored in the INTERSALT study, the largest multinational study on 24 h urinary excretion and BP with 10,079 adults across 48 centres worldwide [66]. This implies that a simultaneous increase in K and a decrease in Na will be beneficial in reducing BP with age and ultimately hypertension incidence [38, 66]. As such, strategies such as taxes on high-salt products, labelling and effective communication, voluntary salt commitment by food industries and legislations for Na reduction are warranted. Similarly, to increase K intake, nutrition promotion of K rich fruits and vegetables may be needed, along with policies that make these foods more accessible and affordable.

A strength of the study is the use of a large nationally representative sample of participants aged 50+ years, in keeping with the aim of WHO SAGE studies. This design on the other hand, may limit generalization to the entire population. Another potential limitation is the recruitment strategy which resulted in more women than men. Women are known to be more likely to volunteer to participate in surveys than men [71], and this has been observed in other 24 h urine collection studies [31, 39]. Akan is the largest ethnic group in Ghana that is well distributed across the entire country [54] which is
why this group was proportionally larger than other ethnic groups in the sample. Additionally, the cross-sectional analysis limits the ability to evaluate the influence of dietary Na and K intake on BP over time. The choice of urine volumes as a sole determinant of completeness of 24 h urine collections requires explanation. Presently, there is no universally accepted standard for determining completeness of 24 h urine collections. The International Consortium for Quality Research on Dietary Sodium/Salt (TRUE), recommends the use of para-aminobenzoic acid (PABA) as being the preferred method [72] but experiences using PABA in African communities is limited and experiences from South Africa [73] suggest that participants may forget or choose not to take their PABA tablets during the urine collection period, thus rendering this method impractical.

The TRUE consortium recognized a need to establish additional measures of assessing 24 h urine completeness beyond PABA. A systemic review found that no single exclusion criteria (24 h urinary creatinine excretion, creatinine index < 0.7, total urinary volume, a combination of creatinine excretion and total urine volume or self-report of missing urine) appeared more accurate in identifying incomplete 24-h urine collections than any others [74]. Importantly, the authors point out that the use of a combination of methods such as creatinine excretion together with urine volume may lead to the unnecessary exclusion of participants with complete urine samples. The reference values used as a cut-off for inadequate urinary collection based on creatinine values has largely been based on those recommended by Stolarski-Skrzypek et al., namely urinary volume < 300 ml, or creatinine excretion < 4 mmol or > 25 mmol for women and < 6 mmol and > 30 mmol for men [28]. The applicability of these creatinine excretion reference values across different ethnic groups has recently been questioned [75]. While the TRUE authors concluded that a creatinine index < 0.7 may best increase the sensitivity of eliminating incomplete urine sampling, they go on to promote the use of similar methodologies used by the INTERSALT and INTERMAP studies as the preferred method to determine 24 h urine completeness in population-based studies [27, 76]. These were as follows: samples that fell outside of the collection time of 22–26 h; participants’ indication that the collection was incomplete and that they had spilled ‘more than a few drops’ of urine; or if total urinary volume was < 250 ml. Given that creatinine is generally variable and largely dependent on muscle mass and protein intake [74], and the reference cut-off values in African populations have not been widely validated, we opted to use 24 h urinary volumes < 300 ml as the measure for incomplete collections. The generally low creatinine excretion values found across the entire cohort suggest a possible low dietary protein intake, but a lack of dietary data precludes further consideration in this regard.

Conclusions
This nationwide study of Ghanaians, using 24 h urinary collections, reported a high intake of salt, accompanied by a low K intake. Increasing urinary Na : K ratio was associated with increasing BP with age. Given the high prevalence of hypertension in the study, our findings identify a need for population-wide strategies to reduce dietary salt intake whilst, at the same time, increase K intake in Ghana.

Supplementary information
Supplementary information accompanies this paper at https://doi.org/10.1186/s12975-020-00979-y.

Additional file 1: Table S1. Na, K, Cl and Cr of original and repeat data in the same participants in Abo-GA. Table S2. Urine results for electrolytes, creatinine and iodine by sex (urine data considered valid if volume > 300 ml). WHO-SAGE Ghana Wave 3. Table S3. Urine results for electrolytes, creatinine and iodine by age (urine data considered valid if volume > 300 ml). WHO-SAGE Ghana Wave 3. Table S4. Salt knowledge, attitudes, and behaviour and fruits and vegetables consumption by age category, sex, and location (n = 875), nested sub study: WHO-SAGE Ghana Wave 3.

Abbreviations

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Disclaimer
The content of this manuscript is solely the responsibility of the authors and does not necessarily represent the official views of the World Health Organization or the funding bodies.

Authors’ contributions
Author contributions were as follows: KC, PK and UV designed the study; RB implemented the research; MJ, IC and EM managed the data and conducted the analysis; NA, KC, JR, AEs wrote the paper; KC takes responsibility of the content of this paper. All authors read and approved the final manuscript.
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Availability of data and materials
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate
The study obtained approval from the WHO Ethics Committee (ARC 4/49) and the University of Ghana Medical School Ethical Review Committee (MESCEREC 44-2) - P 3.1/2005-2006. Participants provided written informed consent following explanation of the study procedure in their home language.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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Appendix I - Determinants of change in blood pressure in Ghana: Longitudinal data from WHO-SAGE Waves 1–3.

RESEARCH ARTICLE

Determinants of change in blood pressure in Ghana: Longitudinal data from WHO-SAGE Waves 1–3

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Abstract

The prevalence of hypertension is increasing in low- and middle-income countries, however statistics are generally derived from cross sectional surveys that utilize different methodologies and population samples. We investigated blood pressure (BP) changes over 11–12 years in a large cohort of adults aged 50 years and older (n = 820) included in the World Health Organization’s Study on global AGEing and adult health (WHO-SAGE Ghana) Wave 1 (2007/8) with follow up in Wave 3 (2019). Participants’ BP was measured in triplicate and a survey completed at both time points. Survey instruments collected information on socio-demographic characteristics, lifestyle, health behaviours and chronic conditions. While no significant difference was found in systolic BP between Waves 1 and 3, diastolic BP decreased by 9.7mmHg (mean = 88.6, 15.4 to 78.9, 13.6 respectively) and pulse pressure increased by 9.5mmHg (44.8, 13.7 to 54.3, 14.1). Awareness of hypertension increased by 37%, from (20% to 57%), but no differences were found for the proportion of hypertensives receiving treatment nor those that had controlled BP. Mixed effects modelling showed a decrease in diastolic BP was associated with increasing age, living in rural areas and having health insurance. Factors associated with an increased awareness of hypertension were residing in urban areas, having health insurance and increasing body mass index. While diagnosis of hypertension has improved over time in Ghana, there is an ongoing need to improve its treatment in older adults.
Introduction

An urgent need to reduce population level blood pressure (BP) is recognized globally by health agencies and governments in order to minimize the associated outcomes of stroke, myocardial infarction, cardiac failure, dementia, renal failure, blindness and premature death (1–2). A 25% relative reduction in the prevalence of raised BP by 2025 is one of the voluntary global targets of the World Health Organization (WHO) for prevention of non-communicable diseases (NCDs), and resources have been developed to assist countries to achieve this target (3–10).

However, progress towards this target has been slow, with hypertension remaining a major health challenge in many countries (9, 11–14).

Worldwide, population level BP has been declining particularly for high and middle-income regions while it has remained stable or has increased among low-income countries. In an extensive analysis of 1479 national, subnational and community studies conducted between 1975 and 2015 in 19-1 million participants, significant reductions in mean systolic blood pressure (SBP) and diastolic blood pressure (DBP) over time were demonstrated (13). In a worldwide study, SBP decreased by 0.8 mm Hg and 1 mm Hg per decade for males and females, respectively, between 1980 and 2008 with substantial reductions reported in Australia, Western Europe and North America (16). However, increased SBP has been recorded in the Oceania, east Africa, and south and southeast Asia for both sexes, and in West Africa for women, ranging from an increase of 0-8-1-6 mm Hg in men and 1-0-2-7 mm Hg in women per decade (16). Furthermore, studies examining BP across the life-course indicate that, while SBP typically increases continuously until age 70 or 80 years, DBP typically rises less steeply than SBP and remains constant or even declines after the fifth to sixth decade of life (17–21). Consequently, an increased pulse pressure (PP) poses a major cardiovascular risk (19, 22–24). However, it remains unclear how changes with age in older adults in regions such as Sub-Saharan Africa (SSA) where population level BP is not declining. With high hypertension rates and low levels of awareness, treatment and control in the African region (25–29), understanding changes over time in older adults is essential in order to reduce associated morbidity and mortality.

To better understand the trajectory of hypertension and predictors of change in BP over time, we aimed to identify changes in population level BP in a nationally representative longitudinal cohort of Ghanaians over an 11–12 year period.

Materials and methods

The study utilized a nationally representative sample of Ghanaians who participated in the World Health Organization’s Study on global Ageing and adult health (WHO-SAGE); a population based longitudinal survey conducted in six low and middle-income countries (LMICs) (China, Ghana, India, Mexico, Russia and South Africa) with the aim to provide support through policy, planning and research (30). For the purpose of this analysis, data from participants 50y and above, included in WHO-SAGE Wave 1 (W1), (2007/2008), were followed up in a preliminary analysis of data from Wave 3 (W3) (2019). The Census Enumerated Areas (CEA) of the 2000 Population and Housing Census was used as the sampling frame. The study design randomly selected 250 enumeration areas (EAs) as the primary sampling units (PSU), nationwide, resulting in 20 strata. The number of EAs to be selected from each strata was based on proportional allocation (determined by the number of EAs in each strata specified on the census frame). In each selected EA, a listing of the households was conducted to classify each household into the following mutually exclusive categories: 1) World Health Survey (WHS)/SAGE Wave 0 follow-up households with one or more members aged 50 years or more; 2) new households with one or more members aged 50 years or more; 3) WHS/SAGE Wave 0 follow-up households which did not include any members aged 50y or more, but
included residents aged 18–49y; and, 4) new households which did not include any members aged 50y or more, but included residents aged 18–49y. Within each EA, 24 households were randomly selected (twenty 50+y households and four 18–49y households). In the 50+y households, all participants 50y and above were selected whereas in 18–49y households only one member was selected, details of which are described elsewhere [31]. At each wave of the study, replacements for losses in the sample were included. We followed up 820 participants with valid BP and self-reported hypertension status data from W1 to W3, as shown in Fig 1. We compared the sociodemographic and health characteristics of the 820 subjects (50+ y olds) included in this work with both the n = 5,904 participants who were excluded (i.e. not followed-up and no valid BP data; n = 4,724–820) and the 79 (i.e. n = 899–820, aged 50+y) subjects who were followed-up but had no valid BP data (See S2 and S3 Tables; all the frequencies were unweighted).

Data collection

While data collection was completed by individual field workers using face-to-face hard copy questionnaires in W1, a computer assisted personal interview (CAPI) approach was utilized in W3 in which field workers, in groups, collected data in assigned EAs. The survey questionnaire
included participants’ sociodemographic characteristics, information of lifestyle-related risk factors and preventive health behaviours, and diagnosis and management of chronic conditions. Participant’s anthropometric data were recorded. Interviews were conducted in the home language of the participants. All field workers received one week of training prior to the implementation of each survey, with support from the WHO-SAGE team, using standardized training and survey materials [32]. In both waves, field workers visited participants in their houses and places of work to conduct interviews. Data collection in each wave was continuous and took approximately a year to complete.

**Study measures**

The main study outcome for this analysis was BP, which was measured using validated wrist-worn BP devices with positional sensors (Omron R6, Kyoto, Japan) [33]. Following 5 minutes of seated rest, three BP readings were recorded on the left wrist (one-minute between each measurement) while the participant sat with legs uncrossed and the wrist positioned precisely at the level of the heart. An average of the second and third readings were used to determine BP. Hypertension classification was made according to the European Society for Hypertension Guidelines (2018), namely systolic ≥140 and/or diastolic ≥90 mmHg [34]. Hypertension status was measured as self-reported treatment or having a measured BP ≥140/90 mmHg, while hypertension awareness was based on self-reported previous diagnosis of hypertension in those with BP ≥140/90 mmHg. Hypertension treatment was determined as self-reported medication use for hypertension in at least two weeks prior to data collection. Hypertension control was assessed as those who self-reported antihypertensive medication use within the last two weeks and had a BP measurement of less than 140/90 mmHg. PP was measured as difference between SBP and DBP, representing the force that the heart generates each time it contracts. Regarding national health insurance status, ‘voluntary’ contributors were defined as those individuals who were not captured by the health insurance scheme as public or civil service workers, while ‘mandatory’ contributors were employees from the public, civil and private sectors. "Current alcohol use" was recorded as "having consumed alcohol in the last 30 days". Physical activity was measured using the Global Physical Activity Questionnaire [35]. Body mass index (BMI) was calculated as weight (kg) / height (m)^2 and classified according to recommendations from WHO [36]. Waist-to-circumference was measured using a flexible tape measure wrapped around the midpoint of the last palpable rib and the top of the hip bone of the participant, ensuring the tape is wrapped over the same spot on the opposite side while the participant is standing with feet together and arms at the sides [37]. Waist to height ratio (WHHR) was then calculated.

Prior to taking part in the study, study measures were explained to participants in their home languages and a written informed consent was obtained for each wave. The study complied with the Declaration of Helsinki with ethical approval from the WHO Ethics Committee (RPC 149) and the University of Ghana Medical School Ethics and Protocol Review Committee (MS-Eu/M.03—P 3.1/2005-2006).

**Statistical data analysis**

Data were analyzed using Stata Statistical Software: Release 16 (StataCorp LLC, 2019; College Station, USA). Due to non-responses for some survey items, the number of responses (n) for each variable are included in the tables. The WHO-SAGE Ghana participants are allocated a unique 10-digit identifier code that facilitates linking of participant’s information over the two waves of the study. Categorical variables were compared using Chi square test while the Wilcoxon Signed Ranked Test was used to compare continuous variables in the cohort over time.
Change in BP was calculated by subtracting the BP measurement obtained in WHO SAGE W1 from that in WHO-SAGE W3. Nonparametric kernel-density plots were constructed with the kdensity command and the default Epanechnikov kernel function utilized. A kernel density plot is a smoothed representation of a histogram with the area under the curve representing the proportion of values compared to all values and sums to 1. Kernel density shows the probability density estimates of the distribution. Mixed model effects regression modelling was used to assess potential predictors of the longitudinal changes in SBP and DBP between W1 and W3. This statistical method for repeated measurements accounts for correlations among measurements within an individual and variations across participants [38, 39]. Logistic regression was used to access factors associated with change in hypertension awareness.

Results
Of the total W1 sample (n = 5,573), 899 participants were aged 50y+ and were followed-up in W3. Of these, 820 respondents had complete data on BP and self-reported hypertension diagnosis. Of the W1 sample (n = 5,110), 820 participants aged 50y+ had complete BP data at both W1 (median age, 59years) and W3 (median age, 71years) and were included in the analysis. The sample comprised 433 (52.8%) men and 387 women (47.2%), with 364 (44.4%) and 456 (56.6%) living in urban and rural areas, respectively.

We further examined sociodemographic and cardiovascular related risk factors and found several changes. There was an increase in the proportion of participants reporting ever attended school which may reflect participation in adult learning literacy programmes in Ghana [40]. WHR, BMI, diagnosis of diabetes and having voluntary health insurance increased in the cohort while current alcohol intake and overall physical activity levels decreased significantly between W1 and W3 (Table 1).

Blood pressure changes within the population
There was no difference in SBP between W1 and W3, however, a significant reduction of 9.7mmHg W1, mean (SD) = 88.6 (15.4); W3, 78.9 (13.6) in DBP was observed over the 11–12 year follow up period. PP significantly increased by 9.4mmHg (95% CI, W1 = 43.9–45.8; W3 = 53.3–55.2). Figs 2 and 3 graphically demonstrate the distributions of SBP and DBP in both waves. While the curves are almost overlapping for SBP, the W3 distribution for DBP is clearly shifted to the left compared to W1.

Hypertension prevalence decreased significantly by 3.2% over the period (W1, 52.0%; CI = 0.48–0.55; W3, 48.8%, CI = 0.45–0.52). Hypertension awareness increased by 37.0% (p < 0.01) over time with no differences observed for hypertension treatment nor the proportion of treated hypertensive participants that had controlled BP (Table 1). Fig 1 illustrates the distribution of hypertension prevalence, awareness, treatment and control in both waves by sex and age. There were significantly more women than men with hypertension in both waves. Hypertension prevalence was highest among the 50–59year group in W1 (51.9%), who were aged 62–71 years in W3 (43.8%).

Predictors of decrease in DBP and increase in awareness of hypertension
A mixed regression model that included change in DBP as the dependent variable found that the observed DBP decrease from W1 to W3 was associated with increasing age, living in rural areas, physical activity and having health insurance (Table 2). Predictors of change in prevalence of hypertension were increasing BMI and residing in rural areas (Table 1). Female gender, ageing, residing in rural areas, increasing BMI having health insurance and diabetes
Table 1. Characteristics of participants in WHO-SAGE Ghana W1 and W3 (n = 829).

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Wave 1</th>
<th>Wave 3</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age in years (mean ± Standard Deviation)</td>
<td>59 (11)</td>
<td>59 (13)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Ever schooled, n (%)</td>
<td>n = 817</td>
<td>n = 820</td>
<td></td>
</tr>
<tr>
<td>Years educated for those who ‘ever schooled’</td>
<td>n = 390</td>
<td>n = 427</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Marital status</td>
<td>n = 820</td>
<td>n = 820</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Married/ cohabiting, n (%)</td>
<td>489 (59.8)</td>
<td>419 (51.1)</td>
<td></td>
</tr>
<tr>
<td>Waist to height ratio (WHR)</td>
<td>0.51 (0.1)</td>
<td>0.53 (0.1)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>BMI</td>
<td>n = 815</td>
<td>n = 747</td>
<td></td>
</tr>
<tr>
<td>Current alcohol use (%)</td>
<td>n = 820</td>
<td>n = 820</td>
<td></td>
</tr>
<tr>
<td>Never</td>
<td>376 (45.9)</td>
<td>452 (51.1)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Current use</td>
<td>240 (29.3)</td>
<td>133 (16.2)</td>
<td></td>
</tr>
<tr>
<td>Yes, but not current</td>
<td>201 (24.5)</td>
<td>235 (28.7)</td>
<td></td>
</tr>
<tr>
<td>Overall Physical Activity, n (%)</td>
<td>n = 812</td>
<td>n = 820</td>
<td>&lt;0.014</td>
</tr>
<tr>
<td>Diabetes, n (%)</td>
<td>n = 820</td>
<td>n = 820</td>
<td>0.645</td>
</tr>
<tr>
<td>Depression, n (%)</td>
<td>n = 820</td>
<td>n = 820</td>
<td></td>
</tr>
<tr>
<td>Health Insurance, Yes, n (%)</td>
<td>n = 820</td>
<td>n = 820</td>
<td></td>
</tr>
<tr>
<td>SBP, mmHg</td>
<td>n = 820</td>
<td>n = 820</td>
<td>0.783</td>
</tr>
<tr>
<td>DBP, mmHg</td>
<td>n = 820</td>
<td>n = 820</td>
<td></td>
</tr>
<tr>
<td>Pulse Pressure, mmHg</td>
<td>n = 820</td>
<td>n = 820</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Hypertension, n (%)</td>
<td>n = 820</td>
<td>n = 820</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>prevalence, n (%)</td>
<td>426 (52.4)</td>
<td>400 (48.8)</td>
<td></td>
</tr>
<tr>
<td>Hypertension awareness (%) hypertension prevalence</td>
<td>n = 820(9.6)</td>
<td>n = 820(11.7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Hypertension treatment (%) hypertension awareness</td>
<td>66 (77.6)</td>
<td>187 (82.9)</td>
<td>0.101</td>
</tr>
<tr>
<td>Hypertension control (%) hypertension treatment</td>
<td>18 (21.6)</td>
<td>99 (51.9)</td>
<td>0.195</td>
</tr>
</tbody>
</table>

All data are presented as median (Interquartile range, IQR) unless otherwise indicated. Whereas walking/cycling refers to such activities completed in a typical week, overall physical activity represents all activities including vigorous, moderate, walking/cycling, vigorous fitness and moderate fitness completed in a typical week. Hypertension prevalence refers to BP ≥140/90 or self-reported treatment while hypertension awareness refers self-reported diagnosis. Hypertension treatment denotes blood pressure medication use (within the last 2 weeks) prior to the survey and hypertension control represents medication use with a measured BP less than 140/90 mmHg. Continuous variables were compared using Wilcoxon signed-rank test; categorical variables were compared using the Chi-Square test.

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predicted an increase in hypertension awareness over the two time periods (Table 3), adjusting for all variables.

**Discussion**

The main finding from this 12 year follow of older Ghanaians is an observed reduction in DBP accompanied by a reduction in hypertension prevalence. While no differences were recorded.
Fig 2. Non-parametric kernel-density estimates for the distribution of SBP (W1, W3 n = 820).
https://doi.org/10.1371/journal.pone.0244807.g002

Fig 3. Non-parametric kernel-density estimates for the distribution of DBP (W1, W3 n = 820).
https://doi.org/10.1371/journal.pone.0244807.g003
in SBP, there was a significant decrease DBP, accompanied by an increase in PP. DBP decreased for every age decile, with those aged 60–69 years at baseline having the greatest reduction over the period. A rise in hypertension awareness over the time was expected since older people are generally higher users of health services. Over the past decade, there has been an increased focus on hypertension screening activities [41] as well as heightened efforts from the health care system in Ghana to implement strategies to address NCDS [42–44]. It was not surprising that hypertension was higher among women than men due to the age of the cohort (50y+).

A lack of change in SBP between the two time periods is in contrast with many other studies that have reported a rise [17, 19, 20]. This may however be explained by the age of the cohort in W3 (median, 71years), and life expectancy in Ghana (64years) [45]. Due to the median age of the cohort, survival bias could not be ruled out, however further investigation in this regard could not be conducted due to lack of access to information on cause and time of death. The observed decline in DBP with advancing age in this older cohort is in agreement with findings from other studies. A review on the epidemiology of hypertension indicated that in most populations, DBP remained stable or reduced after age 50–60yrs [20]. Similarly, data from the Framingham Heart Study, which followed participants for three decades, showed that DBP varied with ageing, increasing until the fifth decade and gradually declining from age 60yrs onwards [19]. These age-related phenomena are explained by physiological changes in arterial structure.
Table 2. Multivariate analysis showing the predictors of decrease in DBP (WHO-SAGE Ghana Waves 1 and 3), n = 794.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Estimate</th>
<th>p-value</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>Ref</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>0.02</td>
<td>0.990</td>
<td>-3.15 to 3.19</td>
</tr>
<tr>
<td>Age</td>
<td>-0.19</td>
<td>&lt; 0.001</td>
<td>-0.36 to -0.02</td>
</tr>
<tr>
<td>Location</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>Ref</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural</td>
<td>-3.63</td>
<td>&lt; 0.002</td>
<td>-5.97 to -1.10</td>
</tr>
<tr>
<td>Marital Status</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>Ref</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not married</td>
<td>-2.36</td>
<td>0.933</td>
<td>-2.68 to -2.92</td>
</tr>
<tr>
<td>Own education (yrs)</td>
<td>-0.30</td>
<td>0.04</td>
<td>-0.58 to -0.01</td>
</tr>
<tr>
<td>Mother education</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than secondary school</td>
<td>Ref</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary school and above</td>
<td>-0.06</td>
<td>0.059</td>
<td>-0.41 to -0.29</td>
</tr>
<tr>
<td>Father’s Education</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than secondary school</td>
<td>Ref</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary school and above</td>
<td>-1.20</td>
<td>0.477</td>
<td>-2.11 to -0.42</td>
</tr>
<tr>
<td>Health Insurance</td>
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</tr>
<tr>
<td>No</td>
<td>Ref</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>-2.60</td>
<td>0.037</td>
<td>-3.03 to -2.16</td>
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<td>BMI1</td>
<td>0.03</td>
<td>0.559</td>
<td>-0.03 to 0.09</td>
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<tr>
<td>Diabetes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>Ref</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>0.31</td>
<td>0.878</td>
<td>-3.63 to 4.24</td>
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<tr>
<td>Ever used tobacco</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>Ref</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>0.88</td>
<td>0.048</td>
<td>1.09 to 3.76</td>
</tr>
<tr>
<td>Overall physical activity</td>
<td>-3.63</td>
<td>0.030</td>
<td>-5.03 to -2.25</td>
</tr>
</tbody>
</table>

Note: Ref represents reference group. Voluntary refers to contributors to health insurance who were not captured by the insurance scheme as public or civil service workers, while mandatory refers to contributors who were employed within the public, civil and private sectors. Overall physical activity represents all activities including vigorous, moderate, walking/cycling, vigorous fitness and moderate fitness completed in a typical week. Multivariate regression was adjusted for age, sex, marital status, years of education, mother’s education, father’s education, health insurance, diabetes and overall physical activity.

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and function. Aging is associated with an increased thickness of the arterial wall, nearly 3-fold between the ages of 20y and 90y, even in the absence of atherosclerotic plaques [46, 47]. An increase in the thickness of the arterial wall is accompanied by an increase in arterial stiffness [48], due to structural and molecular changes in the arteries (decreased elastin content, increased collagen 1 deposition, and calcification—a process termed ‘hardening of arteries’) resulting in a decline in arterial elasticity [49], which in turn induces a decline in DBP [50–52]. Due to the fall in DBP and without any change in SBP in the current study, a reduction in hypertension prevalence was observed. However, this reduction should not be misconstrued to indicate a reduction in cardiovascular risk among the cohort. A longitudinal study that evaluated the risk of cardiovascular mortality emphasized that participants whose DBP decreased
Table 3. Odds ratios showing the predictors of change in hypertension awareness (WHO-SAGE Ghana Waves 1 and 3), n = 369.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>OR</th>
<th>95% CI</th>
<th>p-value</th>
<th>95% CI</th>
</tr>
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<tbody>
<tr>
<td><strong>Hypertension Awareness</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Male</td>
<td>Ref</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>1.98</td>
<td>0.021</td>
<td>1.10–3.30</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>1.05</td>
<td>0.000</td>
<td>1.03–1.08</td>
<td></td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Urban</td>
<td>Ref</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Rural</td>
<td>0.38</td>
<td>0.017</td>
<td>0.37–0.91</td>
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<tr>
<td><strong>Marital status</strong></td>
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<tr>
<td>Married</td>
<td>Ref</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Not married</td>
<td>0.92</td>
<td>0.753</td>
<td>0.54–1.56</td>
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<tr>
<td>Own years of education</td>
<td>1.01</td>
<td>0.589</td>
<td>0.90–1.10</td>
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<tr>
<td><strong>Mother's education</strong></td>
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<tr>
<td>Less than secondary school</td>
<td>Ref</td>
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<td></td>
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</tr>
<tr>
<td>Secondary school and above</td>
<td>1.05</td>
<td>0.053</td>
<td>0.90–1.54</td>
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<tr>
<td><strong>Father's education</strong></td>
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<tr>
<td>Less than secondary school</td>
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</tr>
<tr>
<td>Secondary school and above</td>
<td>0.6</td>
<td>0.644</td>
<td>0.62–0.65</td>
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<td><strong>Health Insurance</strong></td>
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<td></td>
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</tr>
<tr>
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<td>Ref</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>1.99</td>
<td>0.000</td>
<td>1.19–3.33</td>
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<tr>
<td>BMI</td>
<td>1.05</td>
<td>0.002</td>
<td>1.03–1.09</td>
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<td><strong>Diabetes</strong></td>
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<td></td>
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</tr>
<tr>
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<td>Ref</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>7.59</td>
<td>0.000</td>
<td>3.19–16.65</td>
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<td><strong>Overall physical activity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>3.44</td>
<td>0.108</td>
<td>0.92–2.25</td>
<td></td>
</tr>
</tbody>
</table>

Note: Ref represents reference category used for the comparison. Voluntary refers to contributors to health insurance who were not captured by the insurance scheme as public or civil service workers, while mandatory refers to contributors who were employees within the public and private sectors. Overall physical activity represents all activities including vigorous, moderate, walking/cycling, vigorous fitness and moderate fitness completed in a typical week. Logistic regression was adjusted for age, sex, marital status, years of education, mother’s education, father’s education, health insurance, diabetes and overall physical activity.

https://doi.org/10.1371/journal.pone.0244807.g003

with unchanged SBP had a higher cardiovascular mortality compared to those whose SBP and DBP remained constant over time [53]. Similarly, Wittenman et al. reported that, among females, a decline in DBP during a nine-year follow-up was associated with an enhancement of atherosclerotic lesions of the aorta, suggesting that a decline in DBP was a marker for atherosclerosis progression [54], reflecting prevailing compromise of the coronary circulation [50]. Hypertension is a known risk factor for atherosclerosis [55, 56]. Additionally, PP increased significantly due to the declining DBP in the current study, a situation that has the tendency to cause extensive damage to essential organs such as the brain and kidneys [49]. A large PP is associated with a greater risk for myocardial infarction, increased coronary disease and stroke even after effective BP control [52, 55, 57]. PP remains the most powerful independent predictor of cardiovascular risk in the elderly [57, 58]. The observed rise in hypertension awareness may reflect the older age of the participants who have experienced more engagement with health services over time, including routine measurement of BP at clinic visits. Other studies that included largely older participants from
Ghana, China, India and Mexico reported relatively higher hypertension awareness figures [23], compared to whole-of-population studies [24]. Despite the influence of advancing age, increasing hypertension awareness in the Ghanaian population could also be attributed to several health interventions and programmes that have been implemented by the Ghana Health Service (GHS) over the past 15–20 years. The government’s broader development plan was focused on Ghana achieving middle-income country status by the year 2015 through various policies, such as the Ghana Poverty Reduction Strategies (2003–2005, 2006–2009), as well as those driven by the United Nations’ Millennium Development Goals, including the Ghana Shared Growth and Development Agenda, 2010–2013 [43, 46–62]. Concurrent policies with varied mandates were also operationalized such as provision of community-based health planning and services (CHPs), which provided health information services, preventive and curative care for chronic health conditions [24, 63] and increased access to primary healthcare for particularly hard-to-reach communities [64]. In addition, the roll out of the national health insurance scheme in 2003 provided a major boost for services offered by CHPs and increased access to healthcare services in general, as clients were no longer required to provide out of pocket payments for some rendered healthcare services [42]. It is noteworthy that the current study reports of a dramatic increase in voluntary health insurance between W1 and W3.

Along with CHPs, the Ministry of Health, in 2005, introduced the regenerative health and nutrition programme (RHNIP) as part of its effort to curb the rising trend of NCDs [65, 70] while, in 2014, the ministry collaborated with the Novartis Foundation to launch the community-based hypertension improvement program (ComHIP). This program continues to conduct community-based BP screening and BP monitoring in many parts of the country [41].

The finding that more women were hypertensive than men was expected due to the biological changes that take place in women after menopause. Estrogen has been cited to cause endothelial vasodilation, inhibit sympathetic and renin-angiotensin system (RAS) activity, enhance the production of endothelin, reduce oxidative stress, increase antioxidant production and reduce inflammation—all of which regulate BP [66–68]. After menopause, estrogen levels fall causing an increase in hypertension [69–71].

The current study found that increasing age, residing in rural areas, increasing physical activity and having health insurance were associated with a reduction in DBP between W1 and W3. The assertion that BP increases with age has been established [72, 73], however age-related BP may differ according to individual circumstances. Our finding that living in a rural setting was associated with a decline in DBP is consistent with other studies conducted in Ghana.

Data from the Ghana Demographic and Health Survey 2014 which surveyed 13,265 participants nationwide reported lower BP levels in rural compared to urban areas [74]. Similarly, sub-population studies conducted in Ghana have reported lower BP in rural residents compared to their urban counterparts [75, 76]. However, contrasting findings have been reported in other recent African-based comparison studies, indicating a rising BP in rural settings [77–79]. The finding that increasing physical activity is associated with BP reduction is well known [80, 81]. While terms of dose–relationship, engagement in more regular and frequent physical activity results in greater reductions in BP irrespective of age, sex or ethnicity [82, 83].

Increased awareness of hypertension was associated with ageing, female gender, higher BMI, diabetes and having health insurance in the current study. Women were about 2 times more likely than men to be aware of their hypertensive status in the current study. This may be expected as women are known to generally have more interaction with clinics and hospitals through maternal and child health programmes and are known to place more importance on healthcare than men [84]. Furthermore, the sociocultural context [85, 86] may be a disincentive for health-seeking behaviours in men. Increasing BMI predicted hypertension awareness.
This association can be attributed to the higher incidence of hypertension among obese individuals compared to those with "healthy weight" [85, 88]. Increasing body weight is a growing concern in Ghana [89] and a major modifiable cardiovascular risk factor [27]. Those having diabetes were about 7 times more likely to be aware of their hypertensive status than non-diabetics in the current study. Similarly, odds of hypertension awareness among diabetics have been reported [27, 30]. Hypertension is a known risk factor for diabetes [91] and the two conditions mostly coexist [92]. As such, Ghana has introduced clinics in open food markets specifically for diabetes [92] and which simultaneously offers opportunity for BP monitoring.

It was not surprising that having health insurance was associated with a decrease in DBP and an increase in hypertension awareness in the current study. The National Health Insurance Scheme (NHIS) which provides universal access to health care, has over the years improved in its efficiency and increased the range of healthcare services it covers, particularly among those of the lowest socioeconomic status and those most vulnerable groups in the population [93]. The number of outpatient visits increased sharply and health-seeking behaviour was enhanced as a result of the NHIS roll out [55, 56]. As of 2014, the NHIS had 40% coverage of Ghana’s population, an increment of 6.3% from 2010 [97, 98]. The NHIS’s widened access to most healthcare facilities in Ghana may have been an enabling factor in increase in hypertension awareness.

A major strength of the current study was the prospective design that allowed follow up of the same participants in two large countrywide studies of persons aged 50 years and older using the same study design and methodology. Validity of data was achieved using extensively trained teams of interviewers that used standard protocol and instruments and inherent quality control measures. Limitations were the high rate of loss to follow up and the inability to generalize the findings over the entire population because of the higher age of the cohort and lack of weighting applied.

Conclusions
Despite a reduction in DBP recorded between WHO-SAGE Ghana W1 and W3 (2007–2019), hypertension prevalence in W3 remained high. An increase in awareness of hypertension over this time period suggests improved health services for BP monitoring, but this was not accompanied by an increase in the proportion of hypertensive participants who were receiving treatment for the condition, nor improved BP control. Factors associated with a reduction in DBP included increasing age, residing in a rural area and having health insurance, while predictors of hypertension awareness included higher BMI and having voluntary health insurance. This data suggests that existing health programmes should be intensified to improve the management of hypertension in Ghana.

Supporting information
S1 Table. Odds ratio showing the predictors of decrease in hypertension prevalence (WHO-SAGE Ghana Waves 1 and 3), n = 368. (DOCX)

S2 Table. Characteristics of Wave 1 participants included in the study (50+y, n = 820) and those excluded (n = 3,904). (DOCX)

S3 Table. Characteristics of Wave 1 participants included in the study (50+y, n = 820) and those followed-up but excluded from analysis (n = 79). (DOCX)
Acknowledgments

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Disclaimer: The content of this manuscript is solely the responsibility of the authors and does not necessarily represent the official views of the World Health Organization or the funding bodies.

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Formal analysis: Elias K. Menyanu, Barbara Corso, Nadia Minicuci, Ilaria Rocco, Glory Chidamara.

Funding acquisition: Paul R. Kowal, Karen E. Charlton.


Project administration: Nirmala N. Naidoo, Richard B. Brittwum.


Writing – original draft: Elias K. Menyanu.


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Appendix J - Salt reduction strategies may compromise salt iodisation programmes: Learnings from South Africa and Ghana

Applied nutritional investigation
Salt-reduction strategies may compromise salt iodisation programs: Learnings from South Africa and Ghana


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11 Illawarra Health and Medical Research Institute, Wollongong, New South Wales, Australia

ABSTRACT

Objectives: Universal salt iodization has been adopted by many countries to address iodine deficiency. More recently, salt-reduction strategies have been widely implemented to meet global salt intake targets of <5 g/d. Compatibility of the two policies has yet to be demonstrated. This study compares urinary iodine excretion (UIE) according to 24-h urinary sodium excretion, between South Africa (SA) and Ghana; both countries have implemented universal salt iodization, but in Ghana no salt-reduction legislation has been implemented.

Methods: Participants from the World Health Organization’s Study on Global Ageing and Adult Health Wave 3, with survey and valid 24-h urinary data (Ghana, n = 485; SA, n = 923) comprised the sample. Median 24-h UIE was compared across salt intake categories of <5, 5-9 and ≥9 g/d.

Results: In Ghana, median sodium excretion indicated a salt intake of 10.7 g/d (interquartile range [IQR] = 7.6), and median UIE was 152.4 μg/L (IQR = 143.2). In SA, both values were lower: median salt intake = 5.0 g/d (IQR = 3.0), median UIE = 100.2 μg/L (IQR = 129.6). UIE differed significantly across salt intake categories (P < 0.001) in both countries, with positive correlations observed in both—Ghana: r = 0.1551, P < 0.001; South Africa: r = 0.4050, P = 0.0001. Participants with salt intake <5 g/d in SA did not meet the World Health Organization’s recommended iodine intake of 150 μg/d, but this was not the case in Ghana.

Conclusions: Monitoring and surveillance of iodine status is recommended in countries that have introduced salt-reduction strategies, in order to prevent reemergence of iodine deficiency.

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Introduction

Iodine deficiency disorders remain a major global health issue, affecting nearly 2 billion people worldwide and placing them at risk of irreversible brain damage and cognitive impairment. Iodine deficiency causes thyroid dysfunction and is implicated in psychomotor and developmental problems in its mild forms, and cretinism in its most severe form [1]. Populations residing in areas affected by severe iodine deficiency may exhibit learning
difficulties, particularly in children born to women who were iodine deficient while pregnant [9]. The World Health Organization (WHO) in 1991 attempted to address iodine deficiency as a public health concern by recommending universal salt iodization (USI). Many countries have since made excellent progress toward achieving the target of eliminating iodine deficiency disorders [9].

Ghana launched its USI program in 1995 in response to a nationwide survey conducted the year before, which reported that iodine deficiency disorders were endemic in almost half of the 110 districts of the country [41]. Household access to iodized salt fluctuated in the 20 y that followed adoption of USI [4-6]. Recent studies among Ghanaian school-age children (6-12 y) and pregnant women have reported a median urinary iodine concentration (UIC) of 202 μg/L and 155 μg/L, respectively, indicating adequate iodine intake [7,8].

Similarly, in South Africa (SA), low access to iodized salt by many households has led to implementation of a mandatory salt iodization program in 1995 [10]. Following an intensive mass education and health-promotion program related to iodine intake, improved coverage and usage of iodized salt was recorded in the 2005 national survey, with a 155 increase in the number of households using iodized salt and a median UIC of 215 μg/L and 175 μg/L for schoolchildren and adult women, respectively. However, since that time, no further national surveys have been conducted to assess iodine status in SA [11]. South Africa’s mandatory salt-reduction legislation introduced in 2016, in response to WHO’s voluntary target of <5 μg/L, may have implications for the adequacy of iodine intake because of reductions in iodized salt used in processed foods and associated changes in salt use behaviors [12,14], but this has yet to be investigated.

Given that both Ghana and SA have national salt iodization programs but only SA has implemented mandatory salt-reduction legislation, a comparison of salt and iodine intake between these two countries provides an opportunity to investigate the impact of salt legislation on iodine intakes in South Africans, using Ghana as a comparator country. Additionally, an updated evaluation of the effectiveness of the salt iodization programs in both countries will be provided. The aim of this study is to compare urinary iodine excretion across urinary sodium (Na) excretion categories in adult populations from both Ghana and SA.

Materials and methods

This study utilized nationally representative data sets of adults, largely 50 y and older, who were randomly selected to participate in the World Health Organization’s Study on Global Aging and Adult Health (WHO-SAGE) Wave 1 in Ghana and SA. WHO-SAGE Wave 1 was part of the longitudinal multi-country survey developed to compile comprehensive information on the health and well-being of adult populations and respond to their needs through policy, planning, and research. It has been conducted in six low- and middle-income countries-China, China, China, China, and China-Since 2002 [15], with the third wave of the study implemented in 2018-19 in SA and Ghana, respectively. A nested salt subsample was included in Wave 3 in both countries, which included collection of 24-h urine samples for the analysis of Na and iodine concentrations [16].

A total of 5073 participants were recruited for the main WHO-SAGE cohort (Ghana: n = 4488; SA: n = 2534), of whom 5756 with valid survey data (Ghana: n = 3048; SA: n = 2708) were selected. In selecting the main sample to digits with the aims of WHO-SAGE, stratified sampling was conducted to select participants ages 50 y and older, with approximately 30% of adults ages 18 to 49 y as a comparative cohort in each country. In the sample selection, all WHO-SAGE Wave 2 (2015/2016) households were eligible for inclusion in Wave 3 (2018-19) data collection. The sampling frame used in SAGE/Ghana followed a similar design, based on the 2003 World Health Survey/Wave 1 with primary sampling units stratified by region, location, and proportional allocation by size [18]. In SA, participants were selected from probability-sampled enumeration areas using a multi-stage cluster-sampling strategy, with stratification by province, residence, and race. In both countries, replacements for sample attrition used a systematic sampling approach to randomly select new households as previously described [18]. In selecting the nested subsample for this study, participants from randomly selected enumeration areas that provided 24-h urine samples were included. A sample size of 1200 in each country was targeted for the nested salt subsample from the complete WHO-SAGE Wave 3 cohort. Overall, a total of 2310 participants provided 24-h urine samples (Ghana: n = 1121; SA: n = 1189), of which 1902 samples (Ghana: n = 465; SA: n = 767) were deemed to be valid using the criteria of urine volume > 300 mL and creatinine concentration of ≥ 3 mmol/L [19] and availability of corresponding survey (Fig. 1).

In Ghana, teams consisting of three to five interviewers visited participants across the country, taking approximately eight minutes to complete data collection (August 2018–April 2019). In SA, 20 survey teams collected data from participants nationwide over a period of six months (October 2018–March 2019). In both countries, data were collected in the homes and workplaces of participants, using computer-assisted personal interviews. Surveys that included sociodemographic variables and anthropometric and blood pressure measurements were conducted in the home language of participants. All survey teams were trained with support from the WHO-SAGE team, using standardized training, and survey materials [5]. Participants provided 24-h urine samples in 5-L urine bottles containing 1 g thymol, after the collection procedure was thoroughly explained. Thymol has the property of preserving urinary creatinine, Na, and potassium for up to 5 d [20]. In collecting urine, participants were instructed to void the “first urine” but include the “last urine” and note the time of collection: keep the bottles to themselves and collect only their urine; collect all urine passed within the 24-h period; and keep the urine is a cool place [21]. The 24-h urine sample was collected, thoroughly mixed, and volumes recorded, with those kept in cold boxes and transported to the Noguchi Memorial Institute for Medical Research, University of Ghana, in Ghana, and Global Clinical and Virological Laboratories and the North-West University Centre of Excellence for Nutrition, in SA, for quantitative analysis of Na and iodine. Urine samples were stored at −20°C and batch analyzed using the Sandell–Kolthoff method with ammonium persulphate digestion and microplate for iodine analysis and the ion-selective electrode method for Na analysis [21,22]. Sodium (mmol/L) in the 24-h urine sample was converted to total iodine (g/L) using the Formula Na (mmol/24-h urine volume (L)) x 2531 (the molecular weight of NaCl/NaCl x 20 mg Na Cl NaCl).

Participants were categorized with low (<5 g/L), medium (5-9 g/L), or high (>9 g/L) salt intake, and iodine metrics were investigated between these categories. To convert urinary excretion values to estimated daily iodine intake (μg/d), urinary iodine concentration (μg/L) was divided by (72), based on the assumption that approximately 90% of dietary iodine is excreted in urine. A median UIC of 100 μg/L indicates population-level deficiency [23]. Participants’ weight and height were measured with calibrated scales and a stadiometer, respectively. Hyperension status was determined by a measured blood pressure ≥ 140/90 mm Hg or self-reported treatment in the last 2 wk. For salt use behavior questions, responses such as “always” and “often” were combined into “frequent use,” whereas “sometimes,” “rarely,” and “never” were combined as “infrequent use.” The study complied with the Declaration of Helsinki, and ethical approval was obtained from the WHO Ethics Committee (RCP 149), the University of Ghana Medical School Ethics and Protocol Review Committee (no 04/04/03-0500; 2006); the North-West University Human Research Ethics Committee (Pretzfeld, South Africa), and the University of the Witwatersrand Human Research Ethics Committee (Johannesburg, South Africa).

Estimated iodine intake values and urine analyses were compared across three categories of 24-h urinary Na values, equivalent to salt intakes of <5, 5-9, and ≥9 g/L. Normality of the data was checked by visual inspection of histograms and the Shapiro-Wilk test. Categorical variables were evaluated using absolute numbers (percentages), χ2 and Fisher’s exact tests, whereas Mann–Whitney U and Kruskal–Wallis tests explored differences between groups for nonparametric data. Spearman rank-order correlations were used to assess association between iodine concentrations and estimated salt intake, body mass index, and weight. The Pearson correlation coefficient was calculated between log-transformed UI and estimated salt intake. Data were analyzed using Stata software, Release 14 (Stata Corp LLC 2019; College Station, TX, USA).

Results

Of the 2310 participants who provided urine samples, 1202 (52%) had both valid urine and survey data and were included in the analysis. The sociodemographic characteristics of the subsample are compared with those of the main survey sample in Supplementary Table 1. Whereas the SA subsample had significantly older participants than the larger main survey, the Ghana subsample had a significantly higher proportion of younger participants than the main survey. Waist-to-height ratio and diabetes prevalence were significantly higher in the subsamples than in main survey samples in both countries. In Ghana, median UIE was 182.4 μg/ d (interquartile range [IQR] = 162.5), equivalent to a median UIC of...
137.3 μg/L, and median salt intake was 10.7 g/d (IQR = 7.6). In SA, median UIE was considerably lower, at 100.2 μg/L (IQR = 120.6), equivalent to a median UIC of 90.2 μg/L, and accompanied by a lower median salt intake of 5.6 g/d (IQR = 5.0). No significant differences in UIE were found for sex or age category (18–49, 50+) in either country. In the lowest salt category (<5 g/d), UIE indicated suboptimal iodine intake among the SA subsample (72.4 μg/L, IQR = 75.6), but in Ghana it was adequate (UIE = 135.2 μg/L, IQR = 102.7; Tables 1 and 2). UIE significantly increased with increasing salt intake in both SA and Ghana (Fig. 2), with low to moderate correlations observed between UIE and salt intake in each country—South Africa: \( r = 0.1501, P = 0.0011 \) (Table 3); Ghana: \( r = 0.405, P < 0.0001 \) (Table 4). In Ghana, the lower UIC across salt intake categories appears to contradict the increasing UIE values. This can be explained by differences in 24-h urinary volume, such that those with volumes below 1 L/d will have UIC less than UIE. Three quarters (73.3%) of participants with salt intake < 5 g/d had urinary volumes less than 1 L/d, compared with 45% at 5–9 g/d and 9.8% at > 9 g/d.

In the South African sample, there was no association between UIE and anthropometric measures (body mass index, weight, waist and hip circumferences; Table 3), whereas in Ghanaian women UIE was positively correlated with all these measures, controlling for salt intake (Table 4). This may reflect higher intake of food sources of iodine in larger women, presumably related to higher energy intake overall, but lack of
Table 1
Urinary iodine, estimated iodine intake, and sodium excretion values by salt intake equivalent categories, WHO-SAGE Wave 3, South Africa

<table>
<thead>
<tr>
<th>Variable</th>
<th>All (n = 707)</th>
<th>Salt &lt; 5 g/d (n = 313)</th>
<th>Salt 5–9 g/d (n = 233)</th>
<th>Salt &gt; 9 g/d (n = 161)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium (mg/d)</td>
<td>410.3 (269.1)</td>
<td>383.0 (174.8)</td>
<td>433.9 (115.5)</td>
<td>436.6 (141.4)</td>
<td>0.0001</td>
</tr>
<tr>
<td>Salt (g/d)</td>
<td>10.1 (7.6)</td>
<td>10.5 (6.1)</td>
<td>10.3 (6.8)</td>
<td>9.8 (5.5)</td>
<td>0.0001</td>
</tr>
<tr>
<td>BIC (µg/L)</td>
<td>15.2 (12.5)</td>
<td>16.4 (12.2)</td>
<td>15.7 (10.7)</td>
<td>14.1 (11.1)</td>
<td>0.0001</td>
</tr>
<tr>
<td>24-h UIE (µg/d)</td>
<td>192.3 (162.5)</td>
<td>195.2 (120.2)</td>
<td>172.5 (143.2)</td>
<td>200.5 (160.4)</td>
<td>0.0002</td>
</tr>
<tr>
<td>Estimated iodine intake</td>
<td>321.7 (240.9)</td>
<td>330.8 (161.4)</td>
<td>283.0 (128.7)</td>
<td>364.1 (191.8)</td>
<td>0.0001</td>
</tr>
<tr>
<td>Daily iodine intake below EAR for iodine (µg/d, n (%))</td>
<td>502 (43.1)</td>
<td>486 (45.7)</td>
<td>500 (48.7)</td>
<td>500 (48.7)</td>
<td>0.050</td>
</tr>
<tr>
<td>Frequently add salt to food at table, v (%)</td>
<td>50 (41.7)</td>
<td>48 (43.3)</td>
<td>50 (48.7)</td>
<td>50 (48.7)</td>
<td>0.050</td>
</tr>
<tr>
<td>Believe they consume too much salt, v (%)</td>
<td>50 (41.7)</td>
<td>48 (43.3)</td>
<td>50 (48.7)</td>
<td>50 (48.7)</td>
<td>0.050</td>
</tr>
<tr>
<td>Believe a high salt diet is bad for health, v (%)</td>
<td>50 (41.7)</td>
<td>48 (43.3)</td>
<td>50 (48.7)</td>
<td>50 (48.7)</td>
<td>0.050</td>
</tr>
<tr>
<td>Regularity control salt intake, n (%)</td>
<td>225 (42.7)</td>
<td>224 (42.8)</td>
<td>226 (42.8)</td>
<td>225 (42.7)</td>
<td>0.098</td>
</tr>
</tbody>
</table>

EAR, estimated average requirement; BIC, urinary iodine concentration; UIE, urinary iodine excretion.

Data are presented as median (interquartile range) unless otherwise indicated. Continuous variables compared using independent-samples Kruskal–Wallis test.

Table 2
Urinary iodine, estimated iodine intake, and sodium excretion values by salt intake equivalent categories, WHO-SAGE Wave 3, Ghana

<table>
<thead>
<tr>
<th>Variable</th>
<th>All (n = 402)</th>
<th>Salt &lt; 5 g/d (n = 145)</th>
<th>Salt 5–9 g/d (n = 140)</th>
<th>Salt &gt; 9 g/d (n = 140)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
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EAR, estimated average requirement; BIC, urinary iodine concentration; UIE, urinary iodine excretion.

Data are presented as median (interquartile range) unless otherwise indicated. Continuous variables compared using independent-samples Kruskal–Wallis test.

* Daily iodine intake assumed at 24-h UIE (µg/d)×0.02 to account for biovariability.

Fig. 2. Correlation between urinary iodine excretion (UIE, µg/d) and estimated salt intake (g/d).
dietary data prevents further explanation, and this remains speculation at best.

**Discussion**

Our study found that in a sample of South African adults surveyed after introduction of a salt-reduction policy, those with low salt intake (<5 g/d) had inadequate iodine intake (using 24-h UIE as a biomarker of intake), but this was not observed in a sample of Ghanaian adults. Conversely, only South Africans with salt intake above 5 g/d had optimal estimated iodine intake. Ghanaian adults had optimal intake across all salt intake categories. Our data do not support previous reports of frequent use of non-iodized or inadequately iodized salt in Ghana [24]. This study, being the first report of salt and iodine intake levels in SA following implementation of mandatory salt targets for processed foods in June 2016, highlights a risk of inadequate iodine consumption in South Africans who meet the recommended salt intake of 5 g/d or less.

Data from a subsample of WHO-SAGE SA Wave 2 [14] that were collected immediately before implementation of the salt legislation in 2016 by which time some manufacturers may have already reformulated their products [25]—support our current finding. The impact of the SA salt legislation on population iodine intake may be carefully monitored. Fortification levels of iodine in salt may need to be revised accordingly. Based on the current policy mandating iodization of table salt, the results could be interpreted to mean that those in the highest category of salt intake may have been using more table salt (iodized), thus contributing to higher iodine intake, but the lack of dietary data limits further assertion. It has previously been reported that despite manufacturers not being required by law to use iodized salt in processed foods (only salt falls under the legislation), commercial use of iodized salt in the production of processed food is common. Significant amounts of iodine have been detected in a third of foods surveyed, and these were common brands of bread, margarine, and salty snack flavorings [28]. If food manufacturers have previously used iodized salt in food processing, then salt-reduction legislation may inadvertently reduce population iodine intake [26] even if there are no changes in discretionary use of salt.

In Ghana, overall iodine intake was higher than in South Africa across all salt intake categories. Our data are in contrast to previous reports that only a third of households nationwide in Ghana have access to sufficiently iodized cooking or table salt [24,29]. The 2014 Ghana Demographic and Health Survey indicated that 36.3% of women and children lived in environments with no iodized salt [30], and that only four in 10 households consumed salt with adequate iodine [31]. Additionally, traditional street eateries (informal eating places outside the home called “chop bars”) that are popular in Ghana [32] commonly use non-iodized salt in their meal preparation [33]. Low availability and unaffordability of adequately iodized salt, accompanied by low consumer awareness of the importance of using iodized salt [24,31,34,35], have been identified as major setbacks for the effectiveness of the U5 program. Findings from the Ghana Iodine Survey indicated that half of all households in the southern salt-producing areas and approximately half of households in the middle region of Ghana were accessing salt with no added iodine, thus violating Public Health Amendment Law 2012 Act 851 [24,36]. Only 8.6% of households nationally were using salt with iodine levels in the WHO recommended range of 15–40 ppm, suggesting that production methods for salt iodization may have been compromised [24,37]. Chemical analysis of Ghana’s 11 most popular brands of iodized salt indicated that only three met the recommended 50-ppm iodine concentration at retail [38]. Both household and market surveys have also reported that
low availability and high cost of adequately iodized salt are deterrents to accessing the commodity [35]. In the current study, despite known inadequacies in the salt iodization program in Ghana, median UIE was considerably higher in that country than in SA. Other sources of dietary iodine in Ghanaian cuisine warrant further consideration, as well as the use of iodized salt in commercial food processing. This would inform strategies for salt reduction in the country without compromising iodine intake.

Our study found that median salt intake was considerably lower in the SA sample compared to Ghanaians, as expected, because of South African legislation setting maximum permitted salt levels in processed foods [29] and other national health-promotion programs to reduce discretionary salt intake, such as Salt Watch [39]. The high morbidity and mortality associated with non-communica
tible diseases [40] has resulted in many countries embarking on salt-reduction interventions to reduce hypertension and cardiovascular disease [41], but such strategies do not exist in Ghana.

Our analysis is supported by data from WHO-SAGE SA Wave 2 [14] that raised concern that salt-reduction strategies may adversely affect iodine consumption. However, other studies provide conflicting evidence [42-43]. A previous study in South African adults in 2004 reported no difference in median urinary UIE across salt intake categories [13]. The reasons are unclear, but at the time it was assumed that the predominant use of non-iodized salt in the production of processed food products resulted in a lack of difference in iodine across a range of salt intakes. Additionally, national data collected in 2002 showed that 37.3% of households in SA used non-iodized salt at home [44].

Our findings highlight a need for health authorities in Ghana and SA to continually monitor both salt and iodine intake in order to adjust salt iodization levels as required to ensure the compatibility of salt iodization and salt-reduction strategies [45]. Monitoring of salt intake at any point along the food supply chain (production, packaging, storage, retail outlets, and homes) is key to ensuring its efficacy. Greater advocacy efforts are required to result in implementation of healthy food environment policies geared toward the prevention of nutrition-related non-communicable diseases in Ghana. An analysis of 41 food environment policies investigated in the country rated 75% of all good–practice indicators as low [46].

It is also timely for SA to reconsider iodine levels in table salt [47-48], to meet the needs of those with the lowest salt intake while at the same time avoiding excessive iodine supply to areas where salt intake is high. In both countries, coordination and collaboration between government agencies and sectors are needed to harmonize food policies to enhance their effectiveness. A multi-sectoral approach backed by a strong political or social interest from government will be most appropriate.

Strengths of this study include the comparison of salt and iodine intake in two low- to middle-income countries, both with mandatory salt iodization programs but only one with a mandatory salt-reduction policy; a large, nationally representative sample of participants aged 50+ y; and the use of the gold-standard method (24-h urine collection) for measuring salt intake. Limitations include loss of sample size due to incomplete survey or urine collection, and gender disparity, with more women than men likely to provide urine samples in both countries. Data-collection procedures may have created a selection bias for greater participation by those who were home or had flexible employment requirements. A lack of dietary intake data limits our ability to identify which sources of food contributed to total salt or iodine intake in both countries. Additionally, this study excluded pregnant women and children: therefore, further study is warranted among those iodine-sensitive groups.

Conclusions

SA’s salt-reduction strategies, including legislation regarding maximum permitted levels of salt in processed foods, may be compromising population-level iodine intake. In a comparator country, Ghana, that has not introduced salt-reduction policies, population salt intake is considerably higher, and despite reported evidence of a poorly functioning salt iodization program, iodine intake is adequate across all levels of salt intake. Our findings highlight an urgent need to continually monitor the effectiveness of salt iodization programs, especially in countries where salt-reduction efforts are being undertaken to meet WHO’s global voluntary target of population intake of below 5 g/d.

Declaration of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

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Supplementary material

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.nut.2020.11.10065.


Appendix K - Towards Population Salt Reduction to Control High Blood Pressure in Ghana: A Policy Direction

Towards Population Salt Reduction to Control High Blood Pressure in Ghana: A Policy Direction

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Ms. Jemima Okai, BA
Ms. Patricia Mensah, BA

Presented at the conference: “International Conference on Non-Communicable Diseases (NCDs)” held in Accra, Ghana, 15-16 February 2019. The conference was jointly organized by the University of Wollongong and the University of Ghana (NCDs Support Centre for Africa), and was funded through a grant provided by CDC Foundation with financial support provided by Bloomberg Philanthropies as part of the WHO SAGE salt sub-study (its contents are solely the responsibility of the authors and do not necessarily represent the official views of the funding organizations). Additional funding support was received from the Ghana National Petroleum Corporation. Logistics support provided by INQASA BioTec Ghana Limited.
Towards Population Salt Reduction to Control High Blood Pressure in Ghana: A Policy Direction

Elia Menyana,1 Leonard Bantlama,2 Karen Charlton,1,3 Michael Wilson,2 Anna De-Graft Aikins,2 Joanna Russell,3 and Members of the NCDs Support Center for Africa

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ABSTRACT
Although population salt reduction is considered a "best buy" in addressing hypertension and cardiovascular disease, Ghana shares a high hypertension burden with a seemingly high salt consumption. This article discusses best practices in reducing population salt intake and provides preliminary data on salt and potassium intake, as well as the process to develop a road map and identification of actions needed to support the development of a strategic national document towards salt reduction in Ghana. In February 2019, a 2-d stakeholder meeting was held with government agencies, researchers, nongovernmental organizations, civil society organizations, and international partners to deliberate on salt reduction strategies and interventions needed in the face of rising hypertension and other noncommunicable diseases (NCDs) in Ghana. Recommendations were developed from the stakeholder meeting and are being considered for inclusion in the revision of Ghana’s national NCD policy.

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Keywords: salt, hypertension, blood pressure, policy, diabetes, stroke, noncommunicable diseases, Ghana

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Affiliations and Correspondence: The authors report no conflicts of interest.

Introduction
Hypertension was highlighted as the leading risk factor for disability and mortality in the 2017 Global Burden of Disease Study accounting for 10.4 million deaths and 218 million disability-adjusted life years lost (1). One-third of the global hypertension burden is experienced in low- and middle-income countries (LMICs), where, on average, 1 in 3 adults are hypertensive (2). Irrespective of age, the risk of dying from high hypertension in LMICs is more than twice that in high-income countries (HICs). While HICs experienced 7% mortality due to hypertension, LMICs such as those from the African region recorded figures as high as 25% for all persons <60 y (3). The sub-Saharan African region had the greatest burden of hypertension globally as of 2015 (4) and this is projected to increase in the coming decades (5).

Ghana is a country in West Africa with a population of 25,758,108 (6) that is experiencing rapid economic growth, along with an increase in health expenditure (7, 8). Over the past 2 decades, the country has increased its public healthcare spending by 11% (9), however, this has not translated into an expected improvement in human resources (as there is a decline in the number of healthcare personnel) (10) or enhancement of existing healthcare equipment and facilities (9, 11). There has been a reported increase in noncommunicable disease (NCD) in Ghana claiming an estimated 86,200 lives each year (12). The severity of hypertension was demonstrated by Addo et al., where nearly half of people identified with hypertension in Ghana in 2008 had evidence of target organ damage (13). In 2014, health facility-based records indicated that hypertension was the leading cause of disability among adults in Ghana (14). More recent estimates of hypertension prevalence in Ghanaians adults using cohort data of largely 50 y and older, reported a figure of 58.9%, of which 19% were aware of their hypertension status. Of those aware of their hypertension status, 67.6% were receiving treatment but only 11.6% of those being treated had controlled blood pressure (BP) (15). Whilst families, communities, and economies continue to be impacted by this burden, current health systems are unable to adequately manage the large numbers of people with hypertension (16). Preventive strategies are urgently required in Ghana to reduce the hypertension burden, and there are 2 approaches that could be adopted.
Reduction in the prevalence of raised BP could be achieved through a shift in the entire distribution of BP to the left, or through a targeted approach to condense the high-BP tail by implementing intensive clinical interventions to control BP in the hypertensive population (17). The latter approach depends on well-resourced health services, whereas the former requires a public health approach. A pooled analysis of 88.6 million participants demonstrated that a change in mean BP of the population is the main driver of the worldwide change in the prevalence of raised BP (17), providing evidence for the effectiveness of a population-wide strategy.

The habitual consumption of excess salt is a well-known major risk factor for raised BP, and contributes to cardiovascular-related disability and premature deaths globally (18), with 1 in 10 deaths from cardiovascular disease (CVD) being attributed to excessive salt intake (19). Reducing population salt intake has been identified as a voluntary global target to reduce salt intake by 30% by 2025 and a WHO’s “best buy” strategy to reduce the long-term risk of stroke, coronary artery disease, and premature mortality from NCDs (20, 21). Considering this target, international best practice policies, guidelines, and interventions have been developed to reduce excessive salt intake at the population level as part of effort to prevent and control high BP levels. Currently, populations around the world are consuming an average of 9–12 g of salt a day or around twice the maximum recommendation of the WHO (i.e. 5 g/d) (22).

It has been estimated that 2.5 million deaths could be prevented each year if global salt consumption were reduced to <5 g/d (22). Despite considerable progress towards achieving this goal in many countries (23), LMICs in Africa have been slow to adopt salt reduction strategies within their public health priorities. Much of the attention in the past has been on infectious diseases (24) though morbidity and mortality from NCDs are projected to overtake infectious diseases by 2030 (25, 26). With the exception of South Africa and Mauritius, mandatory legislation to regulate salt content in the food supply has not been adopted on the African continent (23).

In Ghana, the majority of the population consume processed foods that are high in salt (14) and report a high use of discretionary salt added to foods at the table and in food preparation (27). Rapid urbanization, population growth, and changing lifestyles have resulted in a rapid nutrition transition in the country and that has resulted in an increased intake of processed foods (28). However, a community-based intervention study has demonstrated that BP could be lowered through behavioral change related to salt reduction strategies (29). As well as salt intake, other lifestyle-related risk factors for CVD include lack of physical activity, smoking, excessive intake of alcohol, and low intake of fruit and vegetables (30).

To address gaps in policy related to public health interventions required to manage the rising prevalence of hypertension and other NCDs in Ghana, an international conference on NCDs was held at the Noguchi Memorial Institute for Medical Research, University of Ghana, on 15-16 February, 2019. The conference was organized by the NCDs Support Centre for Africa at the University of Ghana, in collaboration with the University of Wollongong, Australia, through a grant provided by the CDC Foundation with financial support provided by Bloomberg Philanthropies as part of the WHO Study on global AGEing and adult health (SAGE) salt sub-study. Additional funding support was received from the Ghana National Petroleum Corporation. Sixty-seven participants attended the conference, including representatives from government agencies, academia, non-governmental organizations (NGOs), civil society organizations (CSOs), and international partners. The conference comprised plenary and small group discussions to consider implementation strategies relevant to Ghana, and to plan the way forward for Ghana to adopt a strategy to reduce population-level BP through salt reduction policies. Specific objectives of the conference included:

1. To provide a platform for academics, policymakers, CSO/NGOs, and state actors to be informed and share experiences/lessons in relation to high BP control using salt reduction strategies.
2. To support participants to understand and make use of the evidence on best practice interventions to reduce excessive salt intake in foods.
3. To provide a road map and identify necessary actions to support the development of a strategic national document towards salt reduction in Ghana.
4. Identify opportunities for collaboration, capacity building, and advocacy to ensure the development of a legislative instrument on salt reduction in foods.

Meeting Outcomes

Michael Wilson, Director of the NCD Support Centre for Africa, opened the conference and expressed his appreciation and gratitude for such a gathering of people with an interest in for NCDs in Ghana. Karen Charlton, University of Wollongong, provided a global overview of progress on salt reduction. While highlighting the global NCD targets, she reminded participants of government’s commitment and responsibility to salt, and ultimately hypertension, reduction (22). She explained that food reformulation strategies, either through mandatory or voluntary salt targets have been successful in reducing population salt intakes in the United Kingdom and Australia (31). Multifaceted approaches that include industry salt reduction in foods, food labeling, and consumer education have been successful in various countries. While stressing the feasibility of WHO’s <5 g salt/d recommendation, she highlighted the need to also monitor population iodine concentrations in countries with universal salt iodination (32), particularly for children and lactating mothers who are vulnerable to iodine deficiency disorders (33). Population salt reduction has implication for iodine consumption, as salt is used as the vehicle for iodine fortification. If salt is adequately iodized, a reduction of salt to the recommended level should still provide sufficient iodine (32). The WHO (SHAKE) technical package for salt reduction (acronym standing for Surveillance, Harness industry, Adopt standards for labeling and marketing, Knowledge and Environment) was highlighted as a key resource to assist countries with the development, implementation, and monitoring of strategies to achieve a reduction in population salt intake (34).

Local Situation

Denise Laye, the NCDs program manager of the Ghana Health Service (GHS) identified a need for more research, to generate local ev-
idence on NCDs to inform policy. He stressed the importance of addressing high salt consumption since hypertension is 1 of the top 5 NCDs, with regards costs to the Ghana National Health Insurance Scheme. The composition of salt in traditional Ghanaian foods, such as salted fish, is not well documented. The conference was timely in that the NCD unit of the GHS was in the process of revising its national policy on NCDs and developing strategic plans for its implementation and thus, relevant insights from the conference will inform its development.

Sandra Boatengaa, a postdoctoral researcher, provided new (unpublished) data on food sources that contributed the most salt to the Ghanaian diet. These included bread, bouillon cubes, salted fish or meat, instant noodles, and pizza with rural populations and communities living in the northern region of Ghana consuming more salty foods than those in urban areas, or those in other regions of the country (35). The emergence of energy-dense, nutrient-poor, processed convenience foods such as salty snacks, ready-made baked desserts and sweetened products has dramatically changed the Ghanaian food environment (35). While more than a third (36%) of participants during the 2014 Ghana Demographic and Health Survey reported having consumed salted dried fish on a daily basis (34) the Ghana National Iodine Survey Report 2015 reported frequent and widespread use of bouillon cubes with nearly half (48.8%) of the participants reporting consumption of >5 times a week (36). The importance of salt in Ghanaian cuisine was highlighted by conference delegates as a challenge to changing consumer preferences and food preparation behavior.

Despite the large body of evidence that supports the association between high salt intake and hypertension, very little attention has been given in Ghana in terms of salt reduction policies. Further, only limited small-scale community studies on salt reduction strategies have been conducted (29). WHO-SAGE biostatistician, Núria Minúcic, presented data indicating that much of the NCD burden is preventable or modifiable but stressed that ongoing surveillance is needed to inform policy and to make changes to health systems.

Interventions to Date

Ama de-Graft Aikins, a social psychologist, reported that most of the interventions to address NCDs in Ghana have focused on strengthening 3 of the 6 health system building blocks, namely, information systems, health workforce, and service delivery (37). She recommended the scaling up of interventions that work, making use of cost-effective interventions, addressing NCDs as a developmental issue, and empowering communities to be more aware of the risk factors for NCD development. While identifying NCD interventions, Leanard Baatia, a postdoctoral researcher, drew attention to the fact that, despite the increasing burden of NCDs in Ghana, there has not been any systematic effort to profile existing initiatives and interventions in the country to either prevent or control NCDs. Interventions to date that have targeted hypertension, diabetes, stroke, and cancer prevention and control have been concentrated in urban cities, mostly Accra and Kumasi (38-42).

New Data on Salt Intake in Ghana

The paucity of salt intake data in Ghana has been a setback to the initiation of population-level salt reduction strategies, as evidence is required to drive political commitment and the public health agenda (32). Richard Britwum, the principal investigator of WHO-SAGE, Ghana, provided an overview of the 6-country cohort study, with special reference to WHO-SAGE (Ghana) Wave 3 that has incorporated a nested salt sub-study (43). This sub-study is the first attempt to measure national population salt consumption and assess its association with hypertension and comorbidities in Ghana.

Karen Charlton presented preliminary results on 24-hr urinary sodium concentrations obtained from the WHO-SAGE (Ghana) Wave 3 salt sub-study for one region (Ashanti) out of 10 sampled regions. Mean salt consumption was 8.54 ± 5.33 g/d for men and 10.33 ± 7.91 g/d for women (n = 277), and younger participants, 18-49 y (n = 56) consumed more salt (10.91 ± 7.37 g/d) than older adults aged 50+ y (n = 221) (9.43 ± 7.00 g/d). It was noted that 73.2% and 79.9% of men and women, respectively, had intakes above the WHO’s <5 g/d salt recommendation. Additionally, almost two-thirds fell short of WHO’s potassium recommendations of 90 mmol/d (44).

Though preliminary, this data obtained from one of the most populated regions of Ghana suggests that salt intake is excessively high in both men and women, and among both young and old. Comparatively, salt intake seems to be higher in Ghana compared with South Africa (45), whereas potassium intake appears relatively higher in Ghana. In agreement with Karen Charlton’s finding, Elia Menyrama, a PhD candidate, presented data on salt use behavior from WHO-SAGE, Ghana, Wave 2 data; which showed that Ghanaians added more salt to food during cooking than South Africans, but had much lower levels of obesity and waist circumference measures. As would be expected from major differences in obesity, South Africa had a higher age-standardized prevalence of hypertension than Ghana (46). Differences in determinants of awareness, treatment, and control of hypertension were also evident between the countries, at least for women. Such differences would need to be considered in policy development. It is clear that salt reduction strategies in Ghana would need to focus both on salt reduction in the food supply, as well as efforts to raise consumer awareness on discretionary salt use in cooking and added to foods at the table in Ghana (27).

Discussion

Throughout the conference and in breakout sessions, participants highlighted the essential role of the FDA of Ghana (FDA) in the monitoring and surveillance of the food supply, in relation to NCD risk. It was acknowledged that the standards of the FDA do not include how much sodium is permissible in various food products. Additionally, Ghana does not have food labeling standards nor does it have adequate laboratory facilities to analyze the sodium content of foodstuffs. Representatives from the FDA explained the difficulties and constraints experienced by the directorate from food industry if such regulations were to be adopted and enforced. Another issue that arose from the lively discussion was the fact that the structure of the basic school-level curriculum did not sufficiently
Inform children with life skills about healthy eating habits, including salt consumption. It was agreed that the Ministry of Health (MOH), in collaboration with the Ministry of Education, should make it mandatory to reduce salt in foods served in schools (particularly schools where the government is implementing the National School Feeding Program) as well as in other environments such as workplaces and healthcare institutions.

Despite the existence of a national NCD policy in Ghana (12), a need was identified for more advocacy for NCD prevention, as well as for participants with expert knowledge on NCDs to make themselves available for media communication. There was also a call for stakeholders and researchers to better utilize social media opportunities to ensure dissemination of information on NCDs.

Breakout group discussions addressed the following issues, according to the "SHARE the salt" framework: 1) institutional nutrition standards, 2) industry salt reduction targets, 3) "front of pack labels" for packaged food, 4) reduction of salt in foods prepared outside the home, and 5) behavior change communication to reduce salt use.

**Institutional standards**

The main issues raised included the implementation of the policy on NCDs, which will ensure the targeting of foods containing hidden salts (such as processed and restaurant foods) through legislation and education. Participants discussed a need for the MOH to liaise with other ministries and agencies such as the Ministry of Food and Agriculture (MOFA) and Ministry of Tourism, as well as key institutions to provide a consistent message around salt reduction. The Ghana National Communication Authority (NCA) was identified as a relevant stakeholder in this regard according to its mandate to advocate for consumer education and protection rights. Stiffer control of food advertising of unhealthy foods was identified as a priority.

**Industry salt reduction targets**

There was discussion regarding a need for updated analytical data on food composition in Ghana. Dietary surveys are required to identify foods that are major contributors to total salt intake. Voluntary targets for the food industry regarding maximum salt targets permitted in processed foods were identified as crucial and the roles of NCA, FDA, NGOs, and CSOs as partners in this process was emphasized.

**Front of pack labeling for packaged food**

The FDA representatives reported that nutrition information panels will soon become mandatory for some categories of food products. Food labels are required to be legible and in bright colors to make them easily identifiable. Discussants argued that the FDA should develop guidelines for salt content in food items and identify those products with high salt using consumer signposting warnings, as has occurred in Chile (48). Similarly, there was support for restaurants and food outlets to display the salt content of their products. The FDA was urged to improve its education and advocacy programs to promote healthy diets, particularly aiming to inform vulnerable and hard-to-reach communities. In addition, regulation of advertising on food products needs attention by the FDA.

**Box 1**

Recommendations and action plans for salt reduction strategies in Ghana

- Participants emphasized the urgent need to raise awareness of the relation between excess salt intake and the occurrence of hypertension using various media channels. Given limited policy attention on salt reduction in Ghana, participants agreed on the need for public health education campaigns to reduce the high intake of salt among Ghanaians.
- Foods that contribute large amounts of salt to the Ghanaian diet were to be identified alongside massive consumer education to reduce the intake of such foods or use healthier alternatives.
- The Ghana government and the FDA were to negotiate with food industries and food vendors to voluntarily reduce salt content in their products.
- The FDA was to initiate processes that will ensure that most food products have labels.
- Participants expressed the requirement to explore alternate funding sources to support the implementation of salt reduction interventions. Domestic funding sources from the state, private individuals, and organizations should be explored to support hypertension prevention/control interventions.
- Participants emphasized the need for the provision of adequate resources/facilities for community hypertension screening and information programs.
- The GHS and MOH as well as corporate bodies were urged to facilitate the establishment of modern laboratories with the capacity to analyze the sodium content and other nutrients in food.
- Adequate and accurate salt consumption monitoring and surveillance data are required through national research studies. Periodic capture of data at both community and population levels must be prioritized. A current national nutrition survey is needed to support salt intake data to enhance policy formulation.
- A multistakeholder approach was identified as essential in addressing discretionary salt use. Key stakeholders to be included are MOH, GHS, MOFA, etc.

**Reduction of salt in foods prepared outside the home**

All stakeholders agreed on the need to develop a multistakeholder approach to address excess salt in foods consumed outside of the home, including: consumer sensitization and education about salt use, removal of salt and condiments from eating tables, limiting the consumption of salty snacks, education and training of food vendors, and enforcement of food regulations by the FDA.

**Behavior change communication to reduce salt use**

The sociocultural context was identified as being essential in considering the development of health promotion messages on salt reduction. Discussants suggested using sketches and drama productions in communities to demonstrate the feasibility and benefits of a low-salt diet.
Other strategies that were suggested included the use of persuasive salt reduction messages, the engagement of role models and opinion leaders to act as ambassadors for salt reduction as well as a national educational campaign on salt reduction.

A number of recommendations and associated action plans emerged from the meeting, as summarized in Box 1. These resulted from consensus reached by participants in plenary report-back sessions from breakout groups and represent views that were unanimously shared by participants.

Conclusion

The importance of using multisectoral engagement to promote NCDs has been recognized in the Global Action Plan for the Prevention and Control of NCDs. The outcomes of a high-level stakeholder meeting held in Ghana has recognized the feasibility of such an approach in population-level salt reduction intake in the country, with 9 fraction items identified for inclusion in Ghana’s national NCD policy.

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