MASTER'S DEGREE
PUBLIC HEALTH

Modelling the Impact of Salt Reduction Policies on Cardiovascular Mortality and Morbidity in Southern European Countries

- A Policy Modelling Study for Spain, Portugal and Italy -

Nora Lorenzo i Sunyer

M

2022

SEDE ADMINISTRATIVA

FACULDADE DE **MEDICINA**

INSTITUTO DE **CIÊNCIAS BIOMÉDICAS ABEL SALAZAR**

MODELLING THE IMPACT OF SALT REDUCTION POLICIES ON CARDIOVASCULAR MORTALITY AND MORBIDITY IN SOUTHERN EUROPEAN COUNTRIES

A Policy Modeling Study for Spain, Portugal and Italy

Master's in Public Health Thesis

Nora Lorenzo I Sunyer
EPIUnit/ITR – Public Health Institute of the University of Porto, Porto, Portugal

Supervisor: Prof. Carla Lopes of the Faculty of Medicine of the University of Porto (FMUP) and researcher at the Epidemiology Research Unit of the Public Health Institute-University of Porto (ISPUP)
Co-supervisor: Prof. Milton Severo, Biostatistician, Epidemiologist, Psychometrician, Senior Researcher at Epidemiology Research Unit (EPIUnit) of ISPUP

Porto, September 2022

U.PORTO
FMUP FACULDADE DE MEDICINA
UNIVERSIDADE DO PORTO

ISPUP
INSTITUTO DE SAÚDE PÚBLICA
DA UNIVERSIDADE DO PORTO

Preface

This thesis was developed in the scope of the research activities of the Epidemiology Research Unit (EPIUnit) and the Laboratory for Integrative and Translational Research in Population Health (ITR) from the Institute of Public Health at the University of Porto (ISPUP).

The starting point for the topics chosen for the current study was based on the activities developed in ISPUP as a collaborative center of WHO. Additionally, we had the opportunity to collaborate with Prof. Dr. Maria João Gregório, Director of the National Programme for the Promotion of Healthy Eating of the Directorate-General of Health. Because this National Programme has focused on the implementation of salt reformulation policies, we thought we could take advantage of the current study to evaluate the current policies implemented in Portugal to guide the application of future policies.

Initially we planned to evaluate salt policies in Southern European countries including countries such as Greece. However, as the main author, I have been a resident of Spain, Portugal and Italy, and I had a basic understanding of these three countries' cultural contexts and languages. Therefore, based on the fact that this could facilitate the research process (i.e. obtaining national data required a good level of each national language) and help to put the results into context for each country, we decided to study the impact on Spain, Portugal and Italy.

Acknowledgements

I would like to acknowledge the help of several people without whom I would not have finished this thesis.

I would like to appreciate my kind gratitude to Prof. Dr Carla Lopes, professor of the Faculty of Medicine of the University of Porto (FMUP) and research member at the Epidemiology Research Unit of the Public Health Institute-University of Porto (ISPUP). As the supervisor of this thesis, I would like to thank her for proposing such an interesting topic, supporting me throughout the development of the thesis and trusting my capabilities to do such work.

To, Prof. Dr Milton Severo, Biostatistician, Epidemiologist, Psychometrician, and Senior Researcher at the Epidemiology Research Unit (EPIUnit) of ISPUP, I would like to give my sincere gratitude for conducting all the statistical analysis and helping in the statistical aspects of this thesis.

I would also like to Dr Daniela Correia, a researcher in the EPIUnit of ISPUP, for her contribution in providing the necessary data from the National Food, Nutrition and Physical Activity Survey to conduct this study.

An additional appreciation to Prof. Dr Maria João Batista Gregório, Director of the National Programme for the Promotion of Healthy Eating of the Directorate-General of Health and professor of the Faculty of Nutrition and Food Sciences of the University of Porto. For her contribution to the thesis from a person involved in the implementation of nutrition policies in Portugal.

Especial gratitude to my sister Ariadna for her support and professional guidance throughout the dissertation and to my partner Sabino for the love, care and support he has shown during all this last year.

A general thanks to all my family and close friends that have helped me go ahead and have helped me keep my priorities in order.

Table of Contents

List of Tables

List of Figures

List of Tables in the Annex

Important conversions

5g salt (NaCl) = 2,000 mg Na^+ = 87 mmol (or mEq) Na^+
23 mg Na^+ = 1 mmol (mEq) Na^+
Na^+ = sodium; Cl^- = chloride

ABBREVIATIONS

AESAN – Spanish Agency of Food Security and Nutrition (*Agencia Española de Seguridad Alimentaria y Nutrición*) - Spain
ANIBES – Anthropometry, Intake and Energy Balance (*Antropometría, Ingesta y Balance Energético en España*) - Spain
ARSC – Regional Administration of Health of Central Portugal (*Administração Regional de Saúde do Centro* - Portugal
CV – Cardiovascular
CVD – Cardiovascular Diseases
DGS – Portuguese General Directorate of Health (*Direção-Geral da Saúde*) - Portugal
FBS – Food Balance Sheets
FFQ – Food Frequency Questionnaire
EFSA – European Food Safety Authority
EIPAS – Integrated Strategy for the Promotion of Healthy Eating (*Estratégia Integrada para a Promoção da Alimentação Saudável*) - Portugal
ESC – European Society of Cardiology
EU – European Union
HBS –Household Budget Survey
IAN-AF 2015-16 – National Food, Nutrition and Physical Activity Survey (*Inquérito Alimentar Nacional e de Atividade Física)* - Portugal
IHD – Ischaemic Heart Diseases
INE – Instituto Nacional de Estatística - Portugal; Instituto Nacional de Estadística - Spain
INSA –National Institute of Health Dr. Ricardo Jorge (*Instituto Nacional de Saúde Dr. Ricardo Jorge*) - Portugal
INSEF – National Health Examination Survey (*Inquérito Nacional de Saúde com Exame Físico*) - Portugal
IQR – Interquartile range
ISTAT – National Institute of Statistics (*Istituto Nazionale di Statistica)* - Italy
MMM – May Measurement Month
NAOS – Spanish Strategy for Nutrition, Physical Activity and Prevention of Obesity (*Nutrición, Actividad Física y Prevención de la Obesidad*) - Spain
PHYSA – Portuguese HYpertension and SAlt study - Portugal
PIF – Potential Impact Fraction
PNPAS – National Program for the Promotion of Healthy Eating (*Programa Nacional para a Promoção da Alimentação Saudável*) - Portugal

PRIME – Preventable Risk Integrated ModEL
NCDs – Non-Communicable Diseases
RR – Relative Risks
SBP – Systolic Blood Pressure
SDG – Sustainable Development Goals
WHO – World Health Organization
YLD – Years Lived with Disability
YLL – Years of Life Lost

ABSTRACT

Background and Objectives

In Southern European countries, cardiovascular diseases (CVDs) and high systolic blood pressure are the main causes of death and disability. Excessive sodium consumption, common in these countries, has been positively associated with higher blood pressure, hypertension, and increased risk of CVDs, particularly stroke. Additionally, strong evidence supports that reductions in sodium intake lead to decreases in blood pressure. The implementation of public health policies focused on diminishing the population's salt intake, namely through food reformulation, has been identified as effective to improve cardiovascular (CV) outcomes but the assessment of their impact in Southern European countries has been underexplored. This study aims to evaluate the impact of salt reduction public policies on CV mortality and hypertension in Spain, Portugal, and Italy, to ultimately guide food reformulation policies.

Methods and analysis

Based on data from each country, we identified the top five main contributors to salt intake. In Spain, a national survey (n=2009) using 3-day food diaries they were classified as (1) processed meats, (2) bread, (3) ready-to-eat meals, (4) cheese, and (5) fresh meat. In Portugal, data from the national dietary survey 2015-16 (n=5811) in two 24-h recalls categorised (1) bread, (2) vegetable soup, (3) charcuterie and other processed meats, (4) fresh fish, canned or dry and, (5) cheese. For Italy, a regional study using a food frequency questionnaire reported (1) bread and rolls, (2) processed meat, (3) pizza, crackers and salty snacks, (4) cheese and, (5) other vegetables (canned or preserved). For each country, salt content and daily consumption of each food were taken into account. Food availability/sales trend (2016-2020) from the foods targeted by policies was estimated from household budget surveys (Spain and Italy) or national food balance sheets and sales data (Portugal). The association and correlation between salt intake and systolic blood pressure and the standard deviation for blood pressure were extracted from the literature. Changes in salt intake were examined through five scenarios: (1) salt content reduction based on foods targeted by current policies assuming stable food consumption; (2) scenario 1 plus future policies targeting the top five food contributors; (3) change in food consumption based on the availability/sales trend assuming stable salt content in foods; (4) implementation of current and future policies and changes in food consumption based on the trend; (5) scenario 4 plus a reduction in added salt based on a public health campaign to "reduce 1 pinch of salt a day". The RR was estimated from linear regression coefficients that associated the increased sodium per unit and SBP. Potential Impact Fraction (PIF) was calculated using relative risk (RR) shift based on individual data for salt intake (Portugal) or aggregated data Spain and Italy). Data from the Portuguese national dietary survey 2015-16 was used to access the covariance of individual consumption for all countries in the CV morbidity model. Then, based on the incidence rate, the cases of hypertension prevented per year were calculated for each counterfactual scenario. Changes in CV deaths were estimated employing the Preventable Risk Integrated ModEl (PRIME-WHO).

Results

Current reformulation policies implemented in Spain could lead to a decrease of -10.99% of hypertension incidence and -4.46% of CV deaths, and in Portugal -9.64% and -3.26%, respectively. Implementation of food policies alone (considering current regulations and application of future policies suggested by the current study) could reduce hypertension incidence and CV deaths by -11.85% and -4.80% in Spain, -14.53% and -3.95% in Portugal and, -8.39% and -4.48% in Italy, respectively. If taking into account the changes in consumption according to the availability/sales trend, hypertension incidence would increase by +14.68% and CV deaths by +5.58% CV deaths in Spain, +0.65% more hypertension cases and +0.04% more CV deaths in Portugal and, +0.10% more cases and +0.72% CV deaths in Italy. The combination of salt reduction policies and changes in food consumption could lead to a reduction of -1.38%, -14.04% and -7.29% of hypertension in Spain, Portugal and Italy, respectively. Similarly, this scenario would lower deaths due to CVD by -0.62% in Spain, -3.90% in Portugal and -4.29 in Italy. Lastly, the additional implementation of a public health campaign to decrease added salt would achieve a total reduction in new hypertension cases and deaths due to CVD of -7.41% and -2.86% for Spain, -20.23% and -6.88% for Portugal and, -37.35% and -6.69% for Italy.

Conclusions

This study suggests that the application of salt reformulation policies is effective and necessary to prevent a higher incidence of hypertension and deaths due to cardiovascular diseases. Food availability/sales of the foods targeted by policies is increasing in the three Southern Countries indicating that if no policies are enforced, the incidence of hypertension cases would be expected to increase. Current policies in Portugal might be sufficient to mitigate the impact of this trend, however, in Spain and Italy, the application of future policies that target foods contributing the most to salt intake is needed. Additionally, by applying current and future salt content targets considering the changes in food consumption and the implementation of a public health campaign to reduce “1 pinch of salt a day”, a total of 2,029 deaths could be prevented per year in Spain, 1,536 in Portugal and, 6,626 deaths in Italy.

Background

Cardiovascular diseases (CVDs) are the leading cause of death globally and are positioned among the main top four noncommunicable diseases (NCDs) causing premature deaths worldwide[1,2]. They could be easily prevented through public policies targeting four main risk factors – use of tobacco, harmful use of alcohol, unhealthy diets (high in salt, fat and sugar), and physical inactivity[1]. Together with these modifiable risk factors, hypertension has been identified as one of the leading causes of CVD[2].

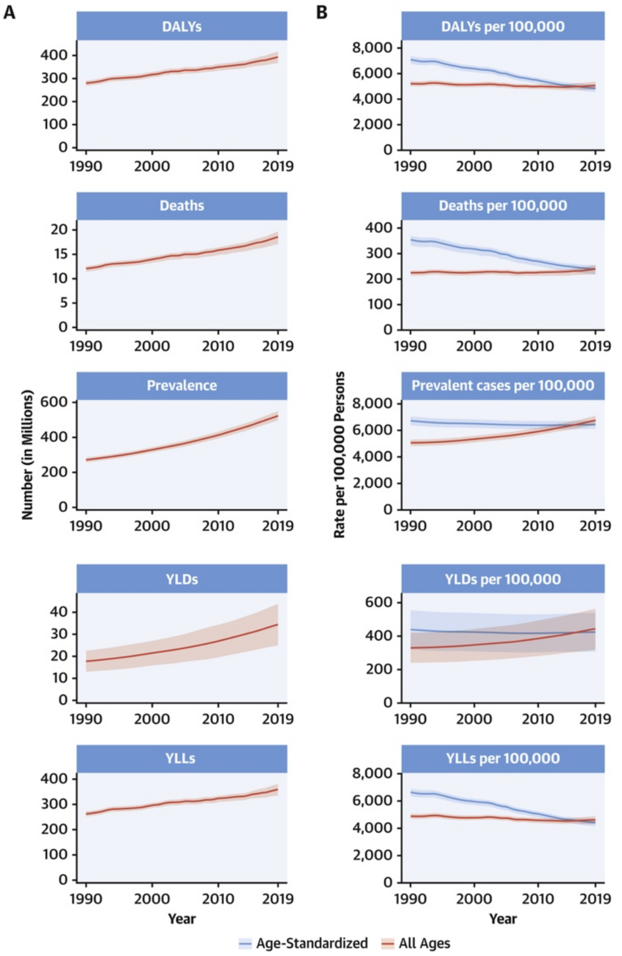
Westernisation of our diet has been characterised by increased consumption of salt, sugar and trans-fat, also known as *unhealthy diets*[3]. This dietary shift was visible between the mid-1980s and the late 1990s when sodium intake in the United States increased by +55%[4]. Dietary patterns are changing and public health policies must adapt to the needs to prevent the NCD burden from getting worse.

1. The Burden of Cardiovascular Diseases

CVDs are the first cause of disability and deaths, mainly due to ischaemic heart disease (IHD) and stroke, affecting 485,620 individuals globally. At worldwide level, crude prevalent CVD cases, all-ages CVDs deaths and years lived with disability (YLD) have increased within the last three decades by +93%, +21.1% and by +94%, respectively, due to the increasing ageing population and other factors such as the obesity epidemic that have exacerbated the underlying problem[5–7]. However, when adjusting the results according to age and population growth, strong declines were found for death rates, disability-adjusted life years (DALYs) and years of life lost (YLL) while prevalent cases had modest reductions (See Figure 1). Age-standardised CVD deaths were reduced by -10.3% between 1980 and 2017. This was the consequence of implementing and/or improving primary prevention interventions (i.e. smoking termination and medical treatment) but the most recent results seem to indicate that decline in death rates has stabilised and is plateauing[6–8].

Similarly, CVDs are still the main cause of death in the European Union (EU) although CVD death rates have lowered by -17.76% between 1990 and 2019. Regarding disability, CVD ranked first in 1990 but after a strong decline of -31.83% in the DALYs rates, neoplasms have now taken the first position for DALYs [9].

Figure 1. Numbers and rates of Cardiovascular Diseases globally between 1990 and 2019.

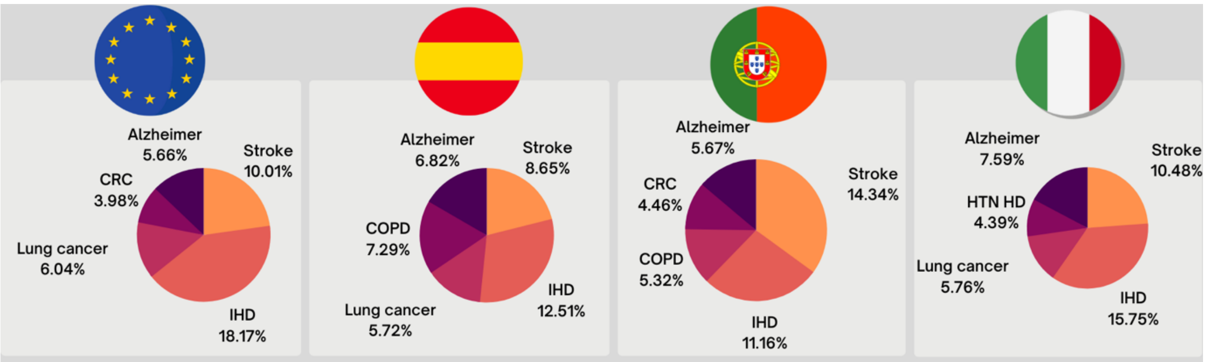


Source: Roth, GA. et al. (2020 *Journal of the American College of Cardiology*, *76*(25), 2982–3021[7]
DALY= disability-adjusted life years; YLDs= years lived with disability; YLLs= years of life lost

1.1. Cardiovascular Mortality in Southern European Countries

Although efforts have been made in Southern European countries to reduce the burden of CVDs, they remain the main leading cause of death among their population. In 2019, IHD accounted for 18.17% of all deaths occurring in the European Union (EU) and 10.01% for stroke. Age-standardized mortality rates have lowered by -17.76% when comparing values from 1990 to 2019 with stronger declines in IHD (-28.35%) than ischemic stroke (-26.68%). In Europe, mortality CV rates adjusted by age and population corresponded to 389.44 deaths per 100,000 compared to 285.72 for Spain, 350.69 for Portugal and 392.13 for Italy. See Figure 2 to understand the contribution of the diseases responsible for more deaths among the EU and Southern European Countries. Patterns of CVD deaths differed between countries, being IHD the most common cause of death in the EU, Spain and Italy, while for Portugal it is still stroke[9].

Figure 2. Contribution of the five causes of death on total deaths in 2019 for the European Union, Spain, Portugal and Italy, respectively.



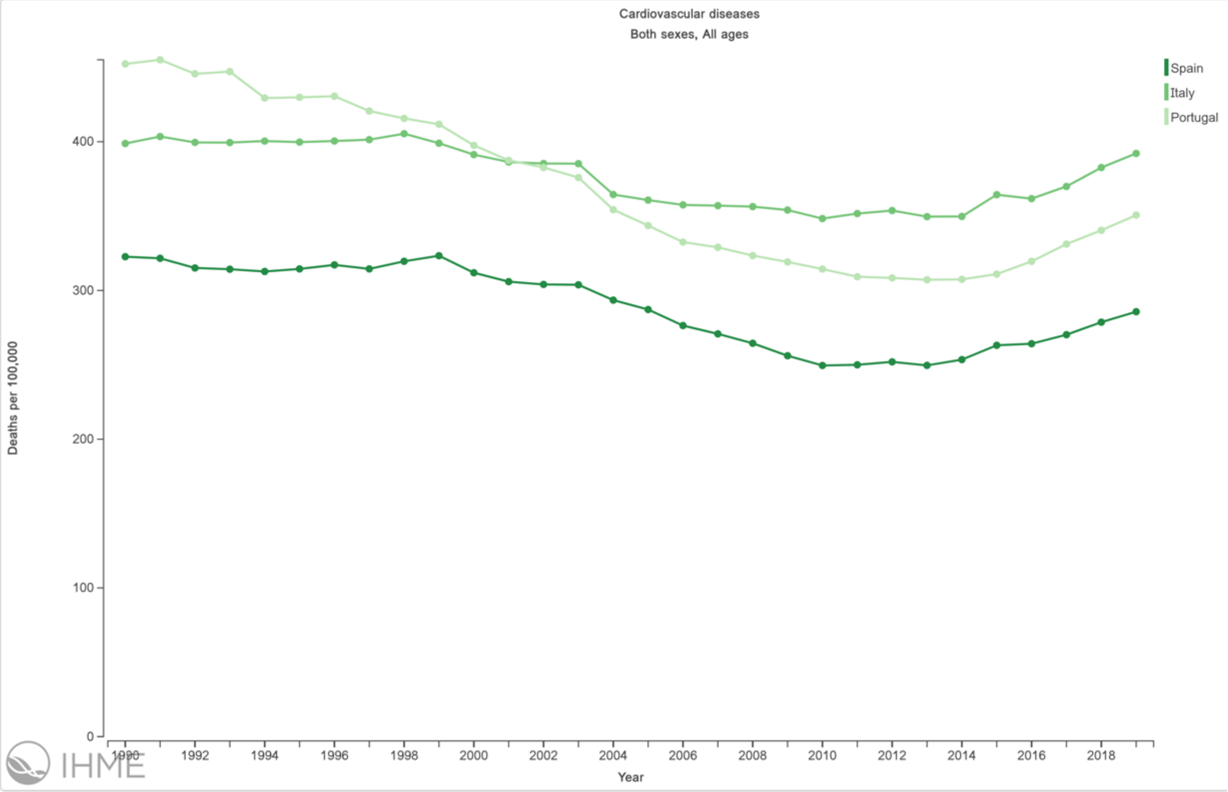
CRC= colorrectal cancer; IHD = ischemic heart disease; COPD = Chronic Obstructive Pulmonary Disorder; HTN HD = hypertensive heart disease
Adaptation based on data from Institute for Health Metrics and Evaluation (IHME). (2022). GBD 2019. University of Washington.

In the Spanish population, CVD mortality declined by –7% among men and -10% among women between 1999 and 2013[10]. IHD is the leading cause of death for men and women with similar reductions (-23.22 and -19.91%, respectively) in death rates between 1990 and 2019. IHD mortality rates for both genders peaked in 1999, dropped intensely until 2013 and then slightly increased. Instead, for ischemic stroke, taking 1990 as a baseline, values decreased until 2013 and then, similarly, raised (See Figure 3)[9].

In Portugal, premature mortality due to CVDs for all ages decreased strongly by -22.47% between 1990 and 2019. Current trends indicate that although CVDs remain the first cause of death for women, neoplasms rank higher than CVDs for men. Each gender presents different patterns of CVDs being ischemic stroke more common among females and IHD for males. Public health campaigns to reduce these numbers were effective, achieving strong decreases of -36.98% and -24.75% of the death rates between 1990 and 2019 for stroke in women and IHD for men, respectively. Death rates achieved the lowest value in 2011 for IHD in men and 2014 for stroke in women and, since then, both have increased mildly (See Figure 3)[9,11].

In Italy, CVD death rates reduced mildly (-1.67%) between 1990 and 2019 but currently, they still account for 34.8% of total mortality[9,12]. As in Spain, IHD is the first cause of death for both genders although, changes in mortality have been stronger in males (-15.12%) than in females (-0.13%). Similarly, for ischemic stroke, death rates lowered -by 14.38% and -30.79% for women and men, as they follow. Trends of IHD and ischemic stroke achieved the lowest death rate value in 2014 and have increased since then (See Figure 3)[9].

Figure 3. Death rates for Cardiovascular Diseases in Spain, Portugal and Italy between 1990 and 2019.



Source: Institute for Health Metrics and Evaluation (IHME). (2022). GBD 2019. University of Washington.

1.2. Hypertension

According to guidelines from the European Society of Cardiology, high blood pressure also known as hypertension is defined as systolic blood pressure ≥140 mmHg and/or diastolic blood pressure levels ≥90 mmHg. However, hypertension is often referred to as high Systolic Blood Pressure (SBP)[13].

High SBP has been a recurrent public health challenge over the last decades, accounting for high rates of disability and deaths[7]. High SBP is an important risk factor for the development of IHD and stroke which explains the high burden of SBP. High SBP was ranked as the fifth leading risk factor worldwide in 1990 and escalated up to the first position by 2007, accounting for 10.4 million deaths and 218 DALYs worldwide in 2017. However, globally, age-standardised DALY rates attributable to high SBP reduced by -25.8% between 1990 and 2017[14].

In the EU and Southern European countries, high SBP remains the main risk factor contributing to more deaths and among the top four risk factors contributing to more DALYs. Age-standardized death and DALY rates lowered by -17.92% and -31.72% in Spain, -22.19% and -39.22% in Portugal and, -17.79% and -36.22% in Italy, respectively, between 1990 and 2019. Furthermore, the progression of high SBP across time follows a similar trend to the one previously presented in Figure 3 for CVD mortality, with the lowest values in 2014 and then gradual increases up to 2019[9].

Crude morbidity and mortality rates due to high SBP have increased from 154 to 235 million DALYs and from 6.79 to 10.8 million deaths between 1990 and 2019. However, age-standardized rates indicate that DALYs, deaths and YLLs decreased during these 29 years. Therefore, these higher crude values can be justified by the consistent population growth and the increased proportion of those aged >70 years old[7].

Furthermore, it is important to consider that undiagnosed hypertension is common and thus, the prevalence of high SBP could be higher than the estimates reported. A study conducted in the United Kingdom estimated that the prevalence of undiagnosed hypertension among patients was close to 5% when considering the benchmarks from the ESC[15]. Aligned with the lack of screening programs, May Measurement Month (MMM) was created. MMM is an initiative developed at a global level to raise awareness about hypertension and as an opportunity to screen the population. In 2017, the MMM assessed the blood pressure levels of 1,128,635 individuals from over 80 countries all over the globe. Results reported that 34.9% of participants examined worldwide had hypertension and 55% for Europe. Mean SBP was reported to be 120.6mmHg globally and 124.1mmHg for Europeans[16]. Based on data from the MMM conducted in 2019, global estimates remained stable (34%) while hypertension among Europeans lowered (43.6%). These values should be interpreted with caution and some estimates could be biased since the participants evaluated are not representative and a convenience sampling methodology is used[17].

In Spain, several studies have determined the burden of high SBP among their population. An early study published in 1998 studied a representative sample of 2,021 persons and estimated that 45.1% had hypertension[18]. A decade later, the ENRICA (*Estudio de Nutrición y Riesgo Cardiovascular en España* - Study on Nutrition and Cardiovascular Risk in Spain)[19] conducted a physical examination of 11,957 individuals between 2010 and 2012 and, concluded that hypertension prevalence was 33.%. Similarly, a nationwide population-based study estimated that the prevalence of hypertension in Spain was 33.3% based on the results from a 2008-2010 study that evaluated a sample of 11,957 individuals aged >18 years and representative of the national population[19].

The 2017 MMM in Spain evaluated 3,849 Spanish participants aged ≥18 and reported that 39.4% of these were hypertensive. Furthermore, they estimated that age and sex-standardized mean was 120.6mmHg for SBP, similar to global values from the 2017 MMM and 3.5 mmHg lower than in Europe[20].

In Portugal, there are a variety of studies assessing the importance of hypertension among the Portuguese population. A study comparing the national health between 1990 and 2016 found that in 2016, approximately 226,000 years of life were lost due to high blood pressure levels and 41% of years of these YLL could have been avoided if behavioural risk factors, such as dietary risks, had been addressed[11].

Prevalence of hypertension in 2003 was estimated to be of 42.1% among the Portuguese population based on a representative sample of 5,023 individuals of ages 18 to 90, being more common among the population aged >64 years old (79% for men and 78.7% for women)[21]. In 2011-2012 the Portuguese HYpertension and SAlt (PHYSA) study[22] conducted a similar study on a representative population of 3,720 individuals from 18 to 90 years old. Prevalence was estimated to be 42.2%, being higher in men than women (44.4% vs. 40.2%).

The National Health Examination Survey (*Inquérito Nacional de Saúde com Exame Físico* - INSEF) [23] provides the most recent outcomes and was the first study to assess the health of a representative population both nationally and from the 7 Portuguese regions. A sample of 4,911 adults with ages between 25 and 74 was evaluated and the prevalence of hypertension reported was 36%, higher in men than women (39.6% vs. 32.7%). These values are lower than previous studies mainly because the INSEF sample was younger and from all over the country. Mean SBP was 125.4mmHg, being 4.8mmHg higher than global 2017 MMM values and 1.3mmHg than Europe.

In Italy, the prevalence of hypertension in the Italian population has been assessed through different studies. A study focused on the trends of blood pressure measurements from the World Hypertension Day, a similar imitative to MMM, found that prevalence remained stable over the period studied being 59% in 2004-2010, 56% in 2011-2012 and, 55.4% in 2013-2014[24]. The World Hypertension Day in 2015 assessed the CV health of 8,657 individuals finding that 36% had hypertension[25]. From 2017, Italy conducted the MMM which allowed to collect more data. The 2017 MMM measured the blood pressure of 10,076 participants aged over 18 years and found that 30.8% of the population had hypertension according to diagnostic criteria. Mean SBP was 129.7 mmHg being the highest from the Southern European countries studied in the current study, 9.1mmHg higher than worldwide levels and 5.6mmHg than Europeans[26].

Regarding other types of assessments, in 2013, Tocci et al.[27] selected a large representative sample of general practitioners and assessed the prevalence of hypertension retrospectively analysing health data from 911,753 individuals. Results indicated that hypertension was prevalent in 25.9% of the individuals, being more common in females than in males (26.5% vs. 25.4%). Values from this latest report were lowered compared to those previously estimated by MMM however, this could be due to undiagnosed hypertension that was not considered for the analysis.

2. Salt and its Health Impact

Sodium is an essential metal for humans and we have developed physiological adaptations to survive on extreme intakes, however, excessive consumption is more common than the lack of it. After sodium has been ingested, it is fully absorbed in the intestine through active transport depending on the body's ability to absorb the rest of the nutrients[28]. Then, approximately half of all the absorbed sodium is distributed in the extracellular fluid, about 45% in the bone and the rest in the intracellular compartment[29].

Sodium is the most prevalent cation in the extracellular fluid and together with potassium, they are key for the homeostasis of the water content in the body. Furthermore, it is also crucial for the membrane potential of the cells, contributes to the never impulse transmission and contraction of the muscles[28].

Sodium concentrations in the body are strictly regulated mainly through excretion in form of urine, sweat and stools, in decreasing order. The kidneys play a key role in regulating the sodium content in the body and consequently its excretion. Renal function filters sodium out of which 99% is reabsorbed. On the one hand, depletion of sodium might be due to lack of consumption and/or excessive loss, producing symptoms like muscle cramps and low blood pressure. On the other hand, excessive sodium increases plasma osmolality and consequently, it enhances water renal retention, resulting in thirst[28].

Therefore, the elimination of sodium results from the cooperation of the renal function, hormonal regulation (i.e. antidiuretic hormone) and other systems, creating a highly efficient system that can adapt to a wide range of sodium intake[28]. However, an acute consumption of salt might produce salt sensitivity a phenomenon that reduces the ability to respond to salt. Consequently, metabolic changes occur, blood pressure can be affected and renal capacity to eliminate the sodium from the body can be limited[30,31]. Salt sensitivity may have a genetic predisposition making certain ethnicities (i.e. African-Americans) more susceptible to having it however, it is also common in the ageing process because renal function diminishes[28].

The impact of excessive salt intake has been studied extensively with most research focused on the effect on cancer and CVDs. High sodium intake might be associated with the development of gastric cancer[32] however, the evidence describing the relationship between CVDs and salt is stronger. Excessive sodium consumption is associated with high blood pressure and hypertension[32–36] and with a 1.12-fold increased risk of CVDs and 1.23-fold increased risk of stroke, respectively[37]. However, the impact that salt intake has on the increased risk of CVDs is thought to be mediated by high blood pressure and not described as a direct relationship[32]. Filippini et al.[36] found that sodium intake was positively associated with the onset of hypertension through a linear relationship. Although previous studies had identified a J-shaped correlation, this was because they had included studies using methodologies to measure sodium intake more likely to be biased and inaccurate (i.e. food frequency questionnaires or 24-h recalls). However, Filippini et al. found that when using the less biased studies, the linear association was very similar to the one for the 24-h urinary excretion studies.

There is strong evidence supporting that reductions in sodium intake lead to decreases in SBP and overall blood pressure[35,37,38] with stronger effects among hypertensive subjects[39–41]. Furthermore, the sodium/potassium ratio has been the focus of recent investigations because potassium intake might affect the impact that sodium has on blood pressure. Research results indicate that low-sodium and/or high-potassium intake could help reduce blood pressure levels. Similarly, low-potassium and high sodium intake were associated with higher blood pressure levels[33,42].

3. Assessment of Population Salt Intake

Globally, a “diet high in sodium” is the third risk factor contributing to deaths among all behavioural risks and the first for those that are strictly dietary[9]. In 2017, worldwide, it was estimated that the impact of high sodium diets corresponded to 3 million diet-related deaths and 70 million diet-related DALYs[43].
Similarly, dietary risk factors have still a strong weight on deaths among Southern European countries, accounting for 10%, 11% and 14% in Spain, Portugal and Italy, respectively. Among all dietary factors, “diet high in sodium” is in the top ten for the three countries for deaths and DALYs. However, deaths and DALYs attributable to high sodium diets have lowered significantly between 1990 and 2019 by -10% and -13.86% in Spain, -3.82% and -19.53% in Portugal and, -22% and -38.55% in Italy, respectively[9].

Sodium is naturally found in foods but is most commonly added as sodium chloride, also known as common salt but can be found in other forms such as glutamate salt, nitrate salt and others. Thus, sodium intake in the diet is complex to quantify.
The scientific community has identified several methodologies to measure it. One of the strategies used to quantify micronutrients, in general, is quantifying food consumption of foods rich in that compound[44]. These nutritional assessments often rely on self-reporting methodologies that can either focus on i) identifying the frequency of how certain foods are consumed using Food Frequency Questionnaires (FFQ), or ii) collecting data on how foods are consumed daily with dietary recalls of either 24 hours or 3 day food diaries.
Unfortunately, in general, dietary self-reporting methods are assumed to be biased due to recall or social desirability[43,45]. Additionally, measuring sodium in the diet is even more difficult to measure compared to other micronutrients, especially when we need to compare data from different periods and data across countries[44]. Therefore, the scientific community has identified sodium biomarkers to evaluate 24-h urinary excretion samples as the reference methodology to estimate salt intake among a national population[46,47]. Currently, it is considered the gold standard because it quantifies up to 93% of the sodium excreted[44,46]. According to the World Health Organization (WHO) recommendations, to estimate sodium intake with a 95% confidence interval (CI) and detect a fluctuation of 12 mmol/d, it is required to measure one 24-h urinary sample of at least 100 to 200 individuals. If the sample size is larger, this will ensure greater precision[48].

Salt intake is different between countries and between individuals living in the same country. According to WHO recommendations, daily salt consumption should be ≤5 g/day to prevent CVDs[47]. However, salt intake across European countries ranges from 7 to 12g per day usually higher in men compared to women. Methodologies to assess consumption differ between European countries which makes it harder to compare the data. However, if only considering countries that used 24-h urinary sodium for the assessment, those with higher intake included Belgium, Hungary, Croatia and Slovenia, and those with lower were Cyprus and Latvia[49].

In Spain, Ortega et al.[50] conducted a study in 2009 focused on a representative sample of 418 participants with ages 18 and 60 from different parts of the country. Based on 24h-urinary sodium excretion they estimated that the average salt intake was 9.8g/day, 11.5g/day for men and 8.4g/day in women, nearly doubling WHO recommendations. Moreover, in 2009, a report from the Spanish Agency of Food Security and Nutrition (*Agencia Española de Seguridad Alimentaria y Nutrición* – AESAN) estimated from two 24h recalls that in the Spanish diet approximately 72% of sodium comes from processed foods, 20% from added salt and 8% is present naturally in the foods[51]. Furthermore, the Anthropometry, Intake and Energy Balance (*Antropometría, Ingesta y Balance Energético en España* – ANIBES) study [52] estimated that based on 3-day self-reporting food diaries in 2013, salt intake among the Spanish population was around 5.06g/day, excluding discretionary salt.

In Portugal, the PHYSA study[22] published in 2014 reported that the average daily salt intake for adults of ages 18 to 90 years old was 10.7g/day per individual, measured in validated 24-hour urinary samples. Later on, the National Food, Nutrition and Physical Activity Survey (*Inquérito Alimentar Nacional e de Atividade Física* - IAN-AF 2015-16)[53] evaluated the salt intake among the Portuguese population from a sample of 6,553 individuals aged between 3 months and 84 years old using two non-consecutive 24-hour recalls. The report estimated that the average salt consumption among the Portuguese population was 7.4 g of salt (2962 mg of sodium chloride), exceeding the 5 grams/day of salt recommendation. Intake was greater among men compared to women (8.58g/day vs. 6.37g/day) and regarding age groups, adults with ages 18 to 64 had the highest intake (7.77g/day). The proportion of non-compliance with the recommended intake was also higher in men than in women (88.9% vs. 63.2%), with male adults of 18 to 64 years old presenting the highest values (92.1%).

Based on collected 24-hour urinary samples of a sub-sample of 95 adults aged 18 to 84 years old of the IAN-AF 2015-16, sodium excretion was estimated to be 4003 mg Na (10.01g of salt) and self-reported sodium from the same sample was 3,489mg (8.72g of salt). Therefore, reporting accuracy between the two 24-h recalls and the urinary sodium biomarkers was estimated to be 0.87 with a misreporting of 514mg of sodium (1.285g of salt) in the self-reporting methods[54]. Even though the results from these different studies cannot be directly compared because of the differences in collection methods used and age groups considered in each study, we believe they are relevant to mention.

In Italy, Malavolti et al.[55] in 2005-2006 assessed salt intake in the northern Italian region of Emilia-Romagna using a validated semi-quantitative food frequency questionnaire. Sodium intake was estimated to be of 5.38g of salt/day (2.15 g of sodium/day).

After a few years, the CUORE project, funded by the Ministry of Health, surveyed individuals from 10 different Italian regions between 2008 and 2012. Within the 2008-2012 CUORE survey, the MINISAL-GIRCSI Study and MENO SALE PIU' SALUTE study [56] was responsible for the quantification of salt intake. Results indicated that from a sample of 1,858 participants aged 35 to 74 years, the average age-standardized salt intake was 10.8g/day for men and 8.3g/day for women, with higher values among men and women aged 45 to 55 years old (11.24 g/day vs. 7.76 g/day) compared to other ages. One decade later, from 2018 until

2019, a second follow-up research was carried out on 1,977 individuals. Results showed a strong reduction of -12.55% in sodium excretion compared to the first study with a salt intake of 9.5g/day and 7.2g/day for men and women, respectively.

4. Main Food Contributors to Salt Intake

Main food contributors refer to those foods that are most responsible for the intake of salt among all foods in the diet. This, mainly occurs because of one of these three conditions:

- The food product has a high salt content;
- Foods consumed in great quantity and daily;
- and combination of the two cases, foods that are consumed relatively often and have a medium-high salt content.

According to the European Food Safety Authority (EFSA) and a cross-country study report, for most European countries 70-75% of all sodium intake comes from processed foods (i.e. ready-to-eat meals, bread, cheeses and processed meats), 10-15% is naturally present in unprocessed foods (i.e. fruits and vegetables) and discretionary sodium (table salt and added during cooking) accounts for 10-15% of total salt intake[28,57].

Regarding food consumption, two 24-h food recall has been identified as the most valid methodology to collect data on food intake that can be compared internationally[44].
A summary of the salt content and food consumption of the main contributors to salt intake can be seen in Table 1.

Table 1. Main Food Contributors to Salt Intake: Salt Content and Daily consumption

COUNTRY	**Contributor**	**Salt Content (g salt/100g product)**	**Daily consumption (g/day)**
			Mean (SD)
SPAIN	Sausages and other processed meats	2.98[58]	40.5 (36.40) [52]
	Bread	1.64[58]	75.0 (45.20) [52]
	Ready-to-eat meals	1.36[58]	70.2 (77.60) [52]
	Cheese	1.04[59]	18.0 (23.00) [52]
	Fresh meat	0.16[60]	103.9 (73.80) [52]
PORTUGAL	Bread and "tostas"	1.33 [53]	108.8 (84.21) [53]
	Soup	0.31 [53]	38.0 (43.64) [53]
	Charcuterie and other processed meats	4.38 [53]	20.8 (30.80) [53]
	Fresh fish, dry or canned	1.29 [53]	46.1 (59.21) [53]
	Cheese	1.94 [53]	20.9 (27.42) [53]
ITALY	Bread and rolls	1.34[55]	78.3 (72.00) [55]
	Processed meat	3.00 [55]	29.5 (24.90) [55]
	Pizza, crackers and salty snacks	1.56 [55]	47.5 (34.20) [55]
	Cheese	1.31 [55]	40.5 (33.90) [55]

	Other vegetables*	0.98 [55]	27.3 (20.00) [55]

*This food category includes processed vegetables such as canned or preserved.

In Spain, the ANIBES Study[52], previously mentioned, identified the main top five contributors to salt intake among the Spanish population using 3-day food diaries. These were **(1)** sausages and other processed meats (19.94%); **(2)** bread (19.77%); **(3)** ready-to-eat meals (12.93%); **(4)** cheese (7.41%); and **(5)** fresh meat (6.17%). Furthermore, another study from the ANIBES study population quantified the daily consumption of these main contributors (mean ± SD): sausages and other processed meats (40.5 g/day ± 36.4), bread (75.0 g/day ± 45.2), ready-to-eat meals (70.2g/day ± 77.6), cheese (18.0g/day ± 23.0), fresh meat (103.9g/day ± 73. 8)[61].
Baseline values of salt content of the top five contributors were 1.04g salt/100g for sausages and other processed meats; 1.64g salt/100g for bread; 1.13g salt/100g of ready-to-eat meals[58]; 1.04g salt/100g of cheese[59]; and 0.16g salt/100g for fresh meat[60].
In summary, sausages and other processed meats stand out because of their salt content. Bread together with ready-to-eat meals and cheese contain average salt content and are consumed in significant amount, except cheese which is consumed less. Lastly, fresh meat contains low amounts of salt but is consumed in large amounts.

In Portugal, the IAN-AF 2015-16 provides data on the salt content and the food consumption of the main products of the Portuguese diet using two non-consecutive 24-h recalls. Based on the results, food categories are also classified based on their micronutrient contribution. Main contributors to sodium intake among the Portuguese population have been identified to be **(1)** bread (18%); **(2)** vegetable soup (8.2%); **(3)** charcuterie and other processed meats (7%); **(4)** fresh fish, canned or dry (5.5%); and **(5)** cheese (3.9%).
The first two products, bread and vegetable soup, are part of the day-to-day Portuguese diet therefore, are consumed in great quantity daily (108.77 g/day and 145.90 g/day, respectively) however, their salt content is not one of the highest (1.33g salt/100g for bread and 0.31g salt/100g for soup). Charcuterie and other processed meats are not consumed so frequently (20.75 g/day) however, these food products, especially in Portugal, are very high in salt content (4.38g salt/100g of charcuterie products). Lastly, the fourth and fifth food category are relevant because of their salt content (1.29g salt/100g for fresh fish, dry or canned and 1.94g salt/100g for cheeses) and their consumption (46.09 g/day for the fourth and 20.85 g/day for the fifth)[53].

Malavolti et al.[55] researched 719 individuals from the north of Italy to evaluate sodium content and conduct an overall assessment of Italian diet. They estimated average daily salt intake to be 2.15g/day but they acknowledge their limitations on quantifying discretionary salt. They used food consumption obtained data from a study of 2005-2006 that used a validated semi-quantitative food frequency questionnaire and a study from 2016-2017 evaluating the salt content of food products. Based on these results, they reported that the main contributors to salt intake were **(1)** bread and rolls (20.21%); **(2)** processed meat (17.68%); **(3)** pizza, crackers and salty snacks (11.22%); **(4)** cheese (9.88%); and **(5)** other vegetables (4.69%). This last food category includes processed vegetables such as canned or preserved.
Bread has an important role in the Italian diet and is consumed daily (78.3g/day) with average salt content (1.35g salt/100g of bread). Similarly to Portugal and Spain, although charcuterie

and processed meats are consumed in less quantity than bread, they stand out because of their high salt content (3.00g salt/100g of processed meats). The fourth and fifth category are consumed frequently (47.50g/day and 40.50g/day, respectively) and have average-high salt content (1.56g salt/100g of pizza, crackers and salty snacks; and 1.3g salt/100g of cheese). Lastly, other vegetables are consumed in less amount (27.30 g/day) and have moderate salt content (0.98g salt/100g other vegetables).

5. Salt Reduction Policies

WHO's *Best Buys* – most cost-effective interventions to prevent and control NCDs – to reduce unhealthy diets include sixteen measures among which, four focus on reducing salt intake[1,62]. Furthermore, policies targeting specific dietary risk factors such as sodium, might also be cost-saving apart from cost-effective[43]. WHO's Member States have approved a global NCDs target of reducing by 30% the population intake of salt to achieve a target of <5 grams of salt (equivalent to 2 g sodium) per day by 2025, and a voluntary global goal to reduce by 25% raised blood pressure by 2025[63]. Similarly, among the Sustainable Development Goals (SDGs), nutrition has been considered "an important factor that crosses all the SDGs"[64]. Southern European Countries are performing poorly (Portugal positioned 20th, Spain 22nd and Italy 23rd out of 31 countries for the SDGs Index Rank) to achieve the 2030 SDGs[65]. Thus, policies focusing on reducing salt intake prevent and control NCDs and bring countries one step closer to accomplishing the SDGs.

Literature shows the positive health impact of salt reduction policies among their population. For example, Breda et al.[66] estimated that for Turkey, a 30% reduction in the salt consumption could have prevented 4,786 deaths in 2017. Additionally, a study conducted by the RIVM (National Institute for Public Health and the Environment in the Netherlands) and the WHO assessed the impact of a 30% reduction in salt intake among nine European countries, including Spain and Italy. Results were very promising, indicating that salt reduction policies could lead to significant improvement on the prevalence and mortality of CVD. Positive health impact was stronger for countries with higher blood pressure values compared to those with lower, which can be explained by the observation that "health benefits of salt reduction are mediated by systolic blood pressure"[67].

5.1. Salt Reduction Policies in Southern European Countries

Sodium reduction policies in Spain, Portugal and Italy, have focused on establishing national initiatives, increasing consumer awareness, labelling and industry involvement[47,68]. Cooperation with the food sector is commonly done through "food reformulation and defining limit levels for salt content in foods and meals" which has been identified as one of WHO's Best Buys to reduce salt intake[1,62].

A summary of all the policies applied through can be seen in Annex II in tables A1, A2, A3 and A4.

In Spain, in 2004, the AESAN implemented the Spanish Strategy for Nutrition, Physical Activity and Prevention of Obesity (*Nutrición, Actividad Física y Prevención de la Obesidad* – NAOS). In the framework of the NAOS strategy, in 2005 the Ministry of Health established an agreement with the Bakers Association to reduce salt content in bread from 2.2g of salt per each 100 grams to 18 (determined by chlorides) in a four-year period[69].
AESAN as the monitoring agency conducted a study that was completed by mid-2008 and verified that in fact, the objective was overachieved and salt content in bread was 1.63g per 100 grams of bread[70]. After several years, a follow-up evaluation determined that in 2014 the average salt content in common bread had remained stable since 2008[71].
During 2016 and 2017, the Spanish Government arranged an agreement with the food industry to establish some salt content targets for the reformulation of several products. Considering 2016 values as baseline, they defined reductions for 2020 for the following categories: -16% in charcuterie and other processed meats; -16% in sauces; -10% in ready-to-eat meals; -13,8% in salty snacks; and -6.7% in vegetable soups. Within these food categories more specific targets have been defined for specific groups (i.e. within sauces, -16% reduction was defined for mayonnaise, -10% for tomato sauce and -5% for ketchup)[72].
Additionally, after the previous success of the 26% decrease in salt on bread in 3 years, in 2019, the Spanish Government approved a regulatory restriction for salt content in bread. The legislation has been enforced in April 2022 requiring common bread to have a maximum of 1.31g of salt per each 100 grams of product (with determination of chlorides)[73].

Portugal has several lines of action at the national level to lower salt intake but also at the regional level. The Regional Administration of Health of Central Portugal (*Administração Regional de Saúde do Centro* - ARSC) has been coordinating two projects at the central region of Portugal: "bread.eat" (*pão.come*) and "soup.eat" (*sopa.come*)[47,74]. The initiative *pão.come* implemented in 2007, involved around 900 bakeries of central Portugal with the aim to achieve the exigent objective of 1g of salt per each 100g of bread (defined afterwards for 2021) by 2013[75]. Later on, in 2009, the ARSC established the *sopa.come* to reach a lower content than 0.5g of salt per soup portion (250ml) in restaurants and canteens by 2013, with intermediate phases to lower the salt concentration progressively[74]. On their latest report, the ARSC reported that *pão.come* reached 97% of the coverage rate in the central region while *sopa.come* achieved 87% in the 1st, 2nd and 3rd grades of basic education; and they were expected to attain the 100% and 88% coverage, respectively, for their 2018-2020 plan [76].
One of the most important national policies in Portugal was the 2009 legislation to reduce salt content in bread (≤1.4 g salt/100 g bread) by -16% (traditional and imported breads were exempt)[47,77]. Later on, in 2012, the Portuguese Government implemented the National Program for the Promotion of Healthy Eating (*Programa Nacional para a Promoção da Alimentação Saudável* – PNPAS) to prevent NCDs[78].

In 2017, the Portuguese General Directorate of Health (*Direção-Geral da Saúde* - DGS) signed the Protocol with the National Institute of Health Dr. Ricardo Jorge (*Instituto Nacional de Saúde Dr. Ricardo Jorge* - INSA) and some associations from the bakery and pastry industry to further decrease salt content by 30% and achieve bread with ≤1 g salt/100 g bread by 2021. Assuming baseline levels in 2017, gradual changes were defined: 1.4 g of salt per 100 g of bread, 1.3 g per 100 g in 2018, 1.2 g per 100 g in 2019 and 1.1 g per 100 g in 2020[79].

In December 2017, Portugal also implemented the Integrated Strategy for the Promotion of Healthy Eating (*Estratégia Integrada para a Promoção da Alimentação Saudável* - EIPAS), the first "health in all policies", comprising seven different ministries to align their policies with the WHO European Food and Nutrition Action Plan 2015-2020 recommendations[80].

Aligned with the recommendations from the European Commission[68], in 2019, the PNPAS and EIPAS signed an agreement with some actors from the food industry to reduce the sodium content in several processed foods. The pact committed enterprises to reformulate foods such as canned soups; ready-to-eat meals; pizzas; breakfast cereals; and other snacks[81]. The monitorization of this program is being conducted by an independent entity, Nielsen, in cooperation with INSA using as main indicators, the yearly average salt content per each food category and the total amount of salt reduced per year. Cooperation with the food industry will persist to promulgate the reformulation of the products considered the major contributors to salt intake that were not taken into account during the first phase of the strategy.

Two Portuguese studies have modelled the impact of food reformulation on cardiovascular outcomes. Goiana-da-Silva et al.[82] modelled the impact of reducing salt content by -16% in eight food categories ("tostas", breakfast cereals; cheese; cookies and biscuits; potato chips and other snacks; processed meats (ham); ready-to-eat soups) and -30% in bread. They estimated a decrease in daily salt intake of 0.5 g and 650 deaths averted in 2016 if targets had been achieved. When assessing the impact of salt, sugar and trans-fats reformulation, they found that salt had the strongest impact in reducing NCD mortality. The second study was conducted by INSA, a "Health Impact Assessment of the Protocol" to reduce bread ≤1 g salt/100 g bread by 2021. Results reported that the effect would be modest and suggested future salt reduction policies should be mandatory and target additional categories[83].

In Italy, in 2007, the Ministry of Health approved the national plan "Gaining health: making healthy choices easier" (*Guadagnare salute: rendere facili le scelte salutari*) to promote healthy lifestyles for the prevention of NCDs [84]. Although the Italian Government has not implemented any regulatory measure to limit salt content in their foods, efforts have focused on cooperating with the industry to establish agreements.

Recently after the national plan was implemented, between 2009 and 2010, they established an agreement with several Baker Associations to reduce salt content by 10-15% in bread and rolls within 2 years. Subsequently, additional commitments have been taken by the industry to diminish by -10% the sodium in frozen foods, including ready-to-eat meals made with pasta or rice and soups [47,85–87]. However, there is no published data on the effectiveness of this food reformulation products.

Similarly to Portugal, the Emilia-Romagna region (Center-North of Italy) implemented the regional initiative of "Bread Less Salt" (*Pane Meno Sale*). The campaign started in 2013 to reduce -15% of the salt content by establishing a maximum of 1.5 salt from the total weight of the flour [88].

6. Justification of the Study

A previous study estimated the impact of reductions in salt consumption on cardiovascular morbidity (prevalence of ischemic heart disease and stroke) and mortality in Spain and Italy. It focused on overall reductions (assuming a 30% reduction of the salt intake or a scenario where salt consumption is <5g/day) in salt intake and it did not identify the impact on hypertension, the main risk factor for cardiovascular outcomes[67].
In the case of Portugal, only one study assessed the impact of current policies however, it only evaluated the potential effect of salt reformulation in bread on blood pressure[83].

There is a gap in the literature of studies that evaluate specific food reformulation policies (i.e. targeting one specific food category) and their impact on CV outcomes. Furthermore, no studies have been found that take into account the "food consumption trend" (changes in availability or sales) of the main foods contributing to salt intake. This could be an important factor underestimated in previous assessments since salt intake depends on salt content but also on food consumption of that food. Therefore, the main aim of this study is to evaluate the impact that specific salt reformulation policies on CV morbidity (hypertension) and mortality in Spain, Portugal and Italy. We included national policies that have been already implemented and future interventions we are proposing focused on targeting the largest contributors to salt intake.

Methodology

1. Sources

The current study required to collect data from many different sources that we have classified according to the data they contained. Find a summary of all the sources used in Annex Table A4.

1.1. Populational Salt Intake

Data using 24-h urinary collection samples of >200 individuals was available for Spain and Italy. Although we prioritized the studies using these methodologies for baseline estimates of daily salt intake, some other factors were taken into account and we used another strategy for Portugal. Find below the studies chosen for each country.

For Spain, we considered the study conducted by Ortega et al.[50] on 418 individuals aged 18 to 60 years considered to be a "representative sample of the Spanish young and middle-aged adult population" and found salt intake to be 9.8g/day. Fifteen different provinces (Spain's autonomous regions) were chosen through random sampling and residents from the region were then randomly selected and contacted through telephone. Included participants were healthy and lived at home (not hospitalized) thus, they were excluded if they had been diagnosed with pathologies such as diabetes or hypertension.

For Portugal, as previously mentioned, the PHYSA study measured sodium excretion from a sample of 3,720 Portuguese, however, we lacked access to the data specific for age and gender which was necessary for the CV mortality model [22]. Therefore, we decided to choose the self-reporting estimates of 7.4g/day from the IAN-AF 2015-16[53]. Although, as previously mentioned, self-reporting methods often lead to under-reporting and 24-h urinary excretion is preferred over dietary intake data[44], we considered a sensitivity analysis correction. The Portuguese National Dietary Survey collected 24-h urinary samples of 95 adults aged 18 to 84 years old from all the IAN-AF 2015-16 sample. Based on the data from these 95 adults they were able to quantify salt intake (10.1g/day) and the accuracy between the two non-consecutive 24-h dietary recall and the 24-h urinary sample[54]. We used these values to conduct a sensitivity analysis and correct individual self-reported salt intake data.

The 2018-2019 CUORE project survey[56] that estimated salt intake was 9.5g/day for men and 7.2g/day for women, has been considered as the reference point for Italian data. They randomly selected age and sex-specific 24-h urinary sodium excretion samples of 100 men and 100 women with ages between 35 and 74 in 10 different Italian regions.

1.2. Salt Content and Food Consumption of Foods

The different counterfactual scenarios of this study considered reformulation for salt content in different food products depending on the country. Current policies in Spain already tackled 60% of the main five food contributors for salt however, only 40% were targeted in Portugal and 0% in Italy (Table 3).

Main food contributors to salt in the diet are calculated using data on the foods consumed and the salt content of that foods. Thus, for each country sources of information for contributors to salt intake included food consumption and salt content which can come from the same or different sources.

For Spain, we considered results from several studies. Within the ANIBES research, we considered two reports, one for the main contributors to salt intake and a second one for evaluating the daily intake of these foods. ANIBES is a cross-sectional study where data was collected from a representative sample of 2,009 individuals with ages between 9-75 years old from 128 sampling points in Spain in 2013. Participants were asked to compile a 3-day food diary (two working days and one weekend day) to evaluate their diet [61].
Food consumption estimates of canned soup were not available from the ANIBES reports thus, we chose the Mercasa report[89] which provided a yearly average intake for soups. In Spain, the category of soups included broths, soups and cream (soup of thicker consistency).
Salt content from national reports that evaluate sodium content through food labelling and laboratory quantification were prioritized over food composition tables because they are more precise and have a better representation of the foods more consumed by the population. These national reports include those with higher sales and as many food categories and food companies involved in the agreement as possible. We considered the 2016 report for the salt content of processed meats, bread and ready-to-eat meals [90]. However, for cheese, we used data from a 2012 report that quantified sodium using chloride determination [59].
No data was available for fresh meat in the national reports thus, we decided to use data from a food composition table. We assumed the average sodium content in fresh meat corresponded to the average of sodium in all meats classified as fresh with equal representation[60].
Lastly, for salty snacks, sauces and canned soup we used results reported in the latest study published in 2020 that included salt content in 2016[72].

In Portugal, the IAN-AF 2015-16 identified the main contributors and provided values of their daily consumption and salt content. The national dietary survey was conducted between 2015 and 2016 and assessed the nutritional habits of 6553 individuals with ages between 3 months and 84 years old. Participants were selected randomly through multistage sampling from the Portuguese National Health Registry including a total of 99 health centres across the national territory. Data was collected through an electronic platform "You eAT&Move" that included three different modules, one of which is the module "eAT24". eAT24 allowed to compile data on food consumption through two non-consecutive self-reported 24-h recalls on adults aged over 10. The platform was connected to food composition tables to use the estimates for nutrient intake such as salt content [91]. Thus, data on salt content and food consumption of the main contributors to salt intake was considered from the IAN-AF 2015-16. Furthermore, we used individual data from the dietary survey for the calculations[53]. However, the IAN-AF reports only salt content for the general category of "soup" thus, to quantify salt content in packaged soup we decided to consider a Portuguese study on the salt content available in the Portuguese market[92].

Salt content for other products such as breakfast cereals, pizzas, chips and salty snacks was considered from a report of the DGS published in 2022 [93].

In Italy, Malavolti et al.[55] led a study that assessed the sodium content of the most common foods in the Italian diet. This research included two different interventions, one focused on evaluating the food consumption among the Italian population, and the second one evaluated the salt content of the foods identified. The first study was carried out in 2005-2006 in the Center-North Italian region of Emilia-Romagna where they evaluated the dietary intake of 719 participants over the age of 18 years. The sample population was identified through random sampling from the Italian National Health Service Registry. They utilized FFQ used within the "European Prospective Investigation into Cancer and Nutrition" known as EPIC-FFQ adapted to the Italian Northern population. Although, as previously mentioned two 24-h recalls are the most preferred methods to evaluate food intake, the EPIC-FFQ is a validated semi-quantitative questionnaire that "assesses frequency and quantity of consumption over an entire year, and takes into account intakes of seasonal food, supporting its substantial validity and reproducibility for the assessment of dietary habits in the adult population"[55].

A second examination was conducted between 2016 and 2017 to evaluate food samples from food markets and grocery stores in Emilia-Romagna based on foods consumed more frequently in that region. Sodium concentrations from the samples were measured using a spectrometer. Results of salt content were considered as baseline values for our study[55].

1.3. "Food Consumption Trend"

By "food consumption trend" we refer to the changes in availability or sales for several food categories over a period of 4 years.

The methodology of the studies considered to estimate the "food consumption trend" at the national level differed between countries. To conduct the calculations for our study we only used these estimates to model a "food consumption trend". Thus, although the methods for each country reported the results in different units, that was not an obstacle to our analysis.

In Spain, the Household Budget Survey (HBS) published yearly by the Ministry of Consumer Affairs gives values on the domestic availability of several food products based on their expenditure. A sample of households (12,000 in 2016 and 12,500 in 2020) was chosen randomly across all the national territory and asked to record their purchases with a scanner. The results report the average annual food consumption (kg/person per year)[94,95].

For the case of Portugal, we considered data from the National Food Balance Sheets (FBS), *Balança Alimentar Portuguesa*, published by the Instituto Nacional de Estatística (INE) on food availability of the main contributors to sodium intake in 2016 and 2020. Although there were HBS available, *Inquéritos Orçamentos Familiares*, the last report was published in 2015-16 which was not ideal for the periods considered in our study. The FBS are published every 5-years (the latest reports were in 2016 and 2020) with yearly estimates of food availability. Based on the annual values, they report results on all food products in g/person per day. The only specific food category to the main contributors to salt intake was cheese, for the other categories we assumed the overall classification. Changes in cereals were attributed to the category of bread and "tostas"; variation in meat to charcuterie and other processed meats; lastly, fresh fish, dry or canned was considered to follow the same trend as overall fish[96]. For soup and "ready-to-eat meals" we considered that availability was stable because we lacked data. However, for policies tackling breakfast cereals, pizzas, chips, and salty snacks we used sales reported by Nielsen IQ per year from 2018 to 2021[93].

The National Institute of Statistics (*Istituto Nazionale di Statistica* – ISTAT) is the responsible body to conduct the HBS in Italy, Spese per consumi: Voce di spesa. Their more recent reports follow the European Classification of Individual COnsumption by Purpose (ECoicop) using an online personal interview. They collect data on the expenditure on goods such as the purchase of foods. Results indicate the average monthly expenditure by household in €. As in Portugal for all the food categories, except for bread, we assumed the food consumption of the most similar or broader category (i.e. for processed meat we considered the values of charcuterie, for cheese we considered values from cheese and dairy products)[97].

1.4. Incidence and Prevalence of Hypertension

Incidence studies was our first choice because it allowed to calculate better the prevented new cases of hypertension in our CV morbidity model. However, incidence was only available for Portugal. In order to calculate an approximative incidence for Spain and Italy, we used the prevalence and incidence of Portugal and the correspondent prevalence in that country (Spain or Italy). This will be further explained in the statistical analysis part.

For Spain, we considered a paper that had studied in 2008-2010 a representative sample of 11,957 Spanish individuals aged over 18 years old. This nationwide population-based study recruited their participants through multistage clustered (municipalities and census) random sampling. Within each cluster, random telephone dialing was used and individuals were chosen according to the gender and age distribution of the Spanish population. A total of 3,983 indviduals had hypertension which indicates a prevalence of 33.3% within this noninstitutionalised population[19].

In Portugal, we used the incidence values from a population-based cohort (EPIPorto) on 796 adults >18years old conducted in 1999-2003. Incidence rate among these non-hypertensive population was found to be 47.3 per 1000 persons-years[98]. Prevalence was taken from the National Health Examination Survey[99], a cross-sectional study that assessed the health of 4,911 individuals aged between 25 and 74 years and reported that the prevalence of hypertension among the Portuguese population was estimated to be 36%. Participants were selected by random sampling from the Portuguese National Health Service database. The survey included a health examination (including blood pressure measurements), a blood sample collection and an interview.

Lastly, in Italy, the prevalence of hypertension was assessed through analysis of patient records from a representative sample of general practitioners distributed across all the Italian regions. General practitioners that agreed to participate in the study, input data measurements of their patients. A total of 911,753 patient records older than 20 years old were evaluated and hypertension was estimated to be prevalent in 26% of the population. Although, undiagnosed hypertension could have been high in this case because only those patients that had been previously diagnosed as hypertensive were included in the estimates[27].

1.5. Population and Mortality data

The National Statistics Institution of each country (INE for Spain, INE for Portugal, and ISTAT for Italy) publish reports including the demographics of their population and mortality causes. We collected data from national censuses[100–102] and causes of death classified according to the International Statistical Classification of Diseases and Related Health Problems, 10th revision (ICD-10). For the cardiovascular mortality model, we needed mortality data that was aggregated in the ICD-10 way considering the following categories I60-I69 cerebovascular diseases; I20-I25 Ischaemic heart diseases; I10-I15 hypertensive disease; I50 heart failure; I71 aortic aneurysm; I26 pulmonary embolism and I05-I09 rheumatic heart disease. However, Italian data was categorized using another coding and for some causes of death, data was aggregated in a different way. We could not assume deaths specific for these specific diseases (C23 – Gallbladder, I10-I15 – Hypertensive disease, I71 – Aortic aneurysm, I26 – Pulmonary embolism, I05-I09 – Rheumatic heart disease). Therefore, we estimated the deaths using data from Spain and made it proportional to the size of the Italian population[103–105].

2. Counterfactual Scenarios

In this study, we assessed the impact of five different counterfactual scenarios on both cardiovascular mortality and morbidity (Table 2).

1) The first counterfactual scenario took only into account a reduction of the salt content based on the current national policies for food reformulation even if they did not target the main contributors to salt intake. Food consumption of the food categories targeted was assumed stable. This scenario was considered for Portugal and Spain but not for Italy (more details on the reason on the next point). Additionally for Portugal, for the current policies targeting breakfast cereals, pizzas, chips and salty snacks, we considered either the expected goal or the current content (if a category had overachieved the goals).
2) The second counterfactual scenario considered not only the current policies but also proposed additional goals based on the EC recommendations[106] for the top five salt contributors that had not been tackled by the policies. Food consumption of the food categories targeted was assumed stable.
3) The third counterfactual scenario took into consideration that only consumption of the foods targeted by policies (either current or future proposed by the current study) changed based on the "food consumption trend" estimates (changes in availability or sales of food products) while maintaining salt content in all food products constant.
4) The fourth counterfactual scenario considered the combination of the second and third scenarios in which both food reformulation and dietary intake differed according to current and future policies.
5) The last counterfactual scenario corresponded to scenario four but with an additional public health campaign to reduce "1 pinch of salt less a day". This would lead to a reduction of the added salt and to reduce discretionary salt overall.

Table 2. Counterfactual Scenarios considered

Counterfactual Scenario	**Salt reformulation based on**		**Food consumption of food products**	**Added salt**
	Current Policies	**Future Proposed Policies**		
1	Reduced based on goals defined	Assumed stable	Assumed stable	Assumed stable
2	Reduced based on goals defined	Reduced based on goals defined	Assumed stable	Assumed stable
3	Assumed stable	Assumed stable	Changed according to "food consumption trend" estimations	Assumed stable

4	Reduced based on goals defined	Reduced based on goals defined	Changed according to “food consumption trend” estimations	Assumed stable
5	Reduced based on goals defined	Reduced based on goals defined	Changed according to “food consumption trend” estimations	Reduction of 1 pinch of salt (considering each pinch of salt to be of 0.36g)

In yellow those categories that were not assumed stable.

Regarding scenario 5, reductions in added salt were calculated based on decreases in discretionary salt. In Portugal, the IAN-AF 2015-16 study [53] estimated that discretionary salt intake was 29% of total salt intake. For Spain, results reported that approximately 72% of sodium comes from processed foods, 20% from added salt and 8% is present naturally in the foods[51]. However, this was not the case for Italy where data on discretionary salt intake is lacking. Based on the Portuguese and Spanish values, a baseline was estimated for Italy assuming that discretionary salt accounted for 20%, similarly to Spain. We recognize this might be an underestimation since for Portugal it was 29%, however, we preferred to have a more conservative approach.

2.1. Policies Considered

The food policies considered in the first and second scenario were different. The first counterfactual scenario considered food reformulation agreements/policies that had been already implemented even if they targeted food categories that were not among the top contributors to salt intake. For the second scenario, we proposed additional targets based on the recommendations from the High-Level Group on Nutrition and Physical Activity (Committee from the European Commission)[106] to reduce by -16% the salt content of the main national contributors. This methodology was also used for some subgroups in the case of Portugal (charcuterie; fresh fish, dry or canned; and cheese) and Spain (cheese and fresh meat). Although agreements had been established with the industry in Italy, no monitoring data of the reformulation effectiveness has been published and the salt content study values from 2016 we considered were after the theoretical reformulation timeline (2010-2012). Therefore, because we did not know if the salt content in bread of 2016 is the result of the reformulation or if it had not happened yet, we assumed that the reformulation had not occurred and we did not consider the first scenario for Italy. In the second scenario for Italy, we proposed to target all food products considered as main contributors.

To get a better overview of the foods targeted by current policies and the ones we are proposing see Table 3.

Table 3. Salt reduction policies considered for the counterfactual scenarios

	SPAIN			PORTUGAL			ITALY†		
	Defined by	**Food category**	**Salt target (g salt/100g)**	**Defined by**	**Food category**	**Salt target (g salt/100g)**	**Defined by**	**Food category**	**Salt target (g salt/100g)**
Current Policies (Scenario 1)	AECOSAN[72]	Sausages and other processed meats	-16% (2017-2020)	The government[79]	Bread and "tostas"	<1 (2021)	-	-	-
		Sauces*		PNPAS[81]	Ready-to-eat meals	<0.3 (2023)			
		Canned soups	-6.7% (2017-2020)		Pizzas	-10% (2019-2022)			
		Ready-to-eat meals	-10% (2017-2020)		Breakfast cereals				
		Salty snacks*	-13.8% (2017-2020)		Canned soups	<0.3 (2023)			
	Legislative change[73]	Bread	<1.31 (2022)		Chips and other snacks	-12% (2019-2022)			
Future Policies proposed (Scenario 2)	Based on EC recommendations[106]	Cheese	-10% (2016-2020)	Based on EC[106] and former Spanish policies[107]	Charcuterie and other processed meats	-16% (2016-2020)	Based on EC recommendations[106]	Bread and rolls	-16% (2016-2020)
								Processed meat	
								Pizza, crackers and salty snacks	
		Fresh meat	-10% (2016-2020)	Based on EC recommendations[106]	Fresh fish, dry or canned	-16% (2016-2020)		Cheese	
					Cheese			Other vegetables	

*Although specific salt targets have been defined for foods within these categories, this study considered the overall reduction proposed for the general food category.

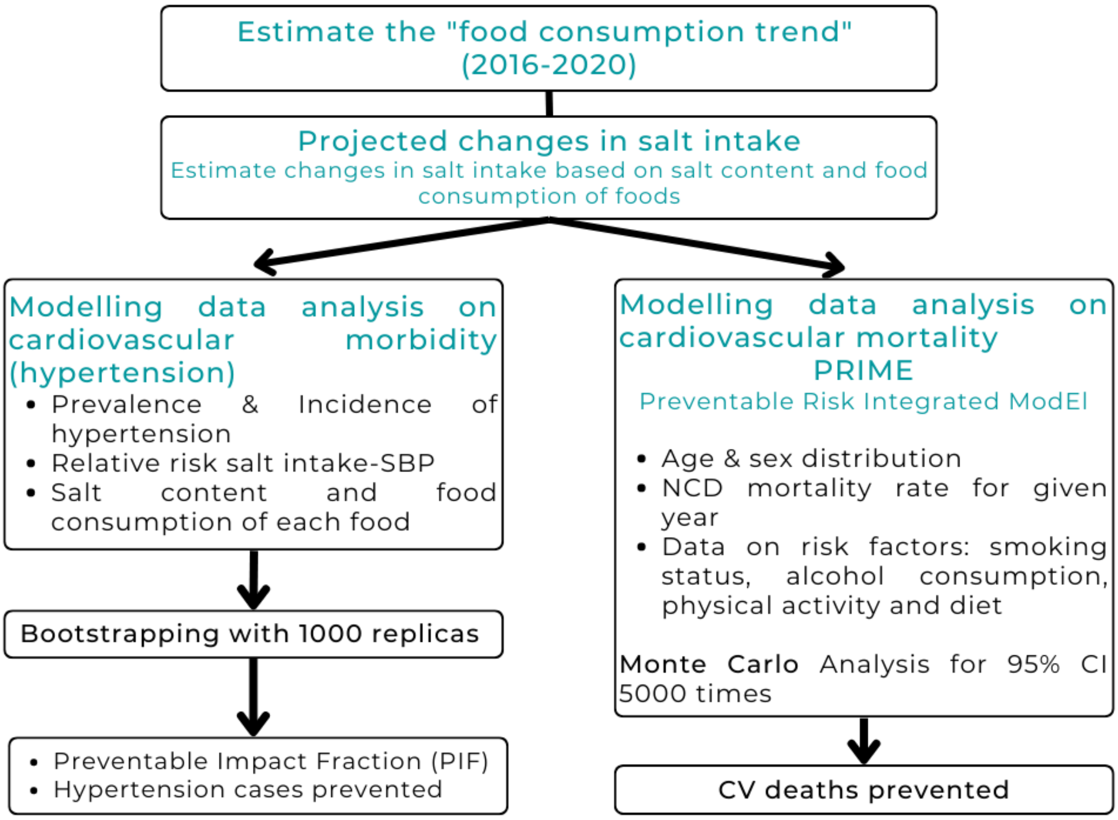
†Agreements have been established with the industry in Italy but no monitoring data of the reformulation effectiveness has been published and the salt content study we considered provides values from 2016 (after the theoretical reformulation timeline of 2010-2012). Because we did not know if the salt content in bread of 2016 is the result of the reformulation or not, we assumed that the reformulation had not occurred. Therefore, for Italy we only considered the proposed future policies.

3. Statistical Analysis

The methodological structure for this current study can be seen in Figure 4. The statistical analysis consisted of two parts. The first part was common for the CV morbidity model and the CV mortality Preventable Risk Integrated ModEL (PRIME). However, the second part was different for each model mainly because the PRIME had already been developed to estimate the impact on CV mortality, however, for CV morbidity we had to develop a new model.

For a more detailed guideline of the data used for each counterfactual scenario see Table A5, A6 and A7 in the Annex.

Figure 4. Methodology structure.



SBP, systolic blood pressure; NCD, non-communicable diseases; PIF, potential impact fraction; CI, confidence intervals; CV, cardiovascular.

3.1. The "Food Consumption trend" (2016-2020)

In this first step used for both the CV morbidity and CV mortality model, we collected food availability/sales statistics from different points in time to ultimately model a "food consumption trend" for all food products considered in scenarios 1 and 2. Then, this trend was used to simulate these changes in the food consumption of each product.

In the case of Spain and Italy, to estimate the trend of the food products (θ), we used the data from food availability and sales in 2016 and 2020. In Portugal, for pizzas, breakfast cereals and chips and other snacks, we also calculated the trend based on sales data from 2018 and 2021. We adjusted the estimates for these three years for the four years of 2016-2020. However, the other food categories in Portuguese FBS already calculated the trend for the other food categories.

(formula 1)

$$\boxed{\theta = \frac{(FCA_{2020} - FCA_{2016})}{FCA_{2016}}}$$

3.2. Projected changes in Salt Intake

We aimed to establish a baseline of salt intake based on food consumption and salt content data. We did not expect this calculation to match the national estimate of salt intake, because it only took into account those foods contributing the most to salt intake or were targeted by foods. However, this rough estimation allowed us to see how salt intake changes in each scenario (i.e. the increase/decrease of salt in each scenario respective to the baseline).

Policies between countries were implemented in different years and food consumption and salt content studies also differed a lot. Fortunately, the "food consumption trend" from 2016 until 2020 was available for all countries and nearly all food products. Thus, to harmonize the period of our study we defined 2016 as the baseline and 2020 as the final year. Meaning that if a study was conducted in 2013, we assumed the results in 2013 as the baseline for 2016. Similarly, we assumed that all policies would have been implemented by 2020, even if they were expected to be enforced after our study period.

To estimate the projected individual salt daily intake if the targets were achieved fully ($\boldsymbol{y_{id}}$), we used the following formula where $\boldsymbol{x_{idf}}$ corresponds to the individual (i) daily consumption (d) of a certain food item (f) and $\boldsymbol{c_f}$ refers to the salt content of the food item assuming salt targets are met.

(formula 2)

$$\boxed{\boldsymbol{y_{id} = \sum_{f} x_{idf} \cdot c_f}}$$

At baseline, daily consumption ($\boldsymbol{x_{idf}}$) and salt content ($\boldsymbol{c_f}$) values corresponded to data extracted from our source studies and assumed that it was representative for 2016. Then, $\boldsymbol{y_{id}}$ was considered as the projected daily salt intake in 2020.

For each counterfactual scenario, we made the correspondent changes to the daily consumption ($\boldsymbol{x_{idf}}$) and salt content ($\boldsymbol{c_f}$) of each food, based on the assumptions described in Table 2 and estimated the daily salt intake ($\boldsymbol{y_{id}}$) in 2020. For scenarios 1 and 2 considering salt reduction policies, we changed salt content $(\boldsymbol{c_f})$ of each food according to the reduction expected if the target was achieved by 2020. For scenario 3, daily consumption $(\boldsymbol{x_{idf}})$ was modified according to the "food consumption trend" calculated (i.e. if the "food consumption trend" of bread was expected to increase by +51%, we multiplied food consumption of bread by 1.51). Scenario 4 included a combination of adjustments (reduction salt content and decrease/increased daily consumption) in salt content $(\boldsymbol{c_f})$ and daily consumption $(\boldsymbol{x_{idf}})$. Lastly, in scenario 5, we considered the same changes as counterfactual scenario 4 but with additional modifications in the daily consumption $(\boldsymbol{x_{idf}})$ of discretionary salt. More specifically, for this last scenario, we assumed a reduction of "1 pinch of salt less a day" (1 pinch of salt = 0,36 of salt) of the discretionary salt for each country.

After the necessary changes, we obtained the expected daily salt intake $(\boldsymbol{y_{id}})$ in 2020 for each scenario. We then proceeded to calculate the change in daily salt intake (∂) between the baseline $(\boldsymbol{y_{id\ baseline}})$ and each counterfactual scenario $(\boldsymbol{y_{id\ scenario}})$.

(formula 3)

$$\boxed{\partial = \frac{(\boldsymbol{y_{id\ scenario}} - \boldsymbol{y_{id\ baseline}})}{\boldsymbol{y_{id\ baseline}}}}$$

When conducting the calculations, we believed it would be interesting to also consider additional baselines. The first was to evaluate the change between counterfactual 3 and 4 to the third, to represent in our results what would be the impact if no policies were applied, and food consumption changed according to the tendency. The second accounted for the differences between counterfactual 5 to the fourth to evaluate how would salt intake reduce if a public health campaign of "1 pinch of salt less a day" was implemented. Thus, scenario 3 and scenario 4 were considered as the baseline, respectively, for these two considerations.

3.3. Modelling Data Analysis on Cardiovascular Mortality

NCDs' scenario models have been developed to estimate the effect of population-level interventions and help establish a priority criterion when considering the health impact of different strategies. In this case, we used the PRIME November 2017 version, an openly available NCD scenario model[108]. The PRIME modelling tool allows to evaluate the impact at the population level when changing specific NCD risk factors on the annual deaths from NCDs[109]. This tool has been developed by researchers at WHO Collaborating Centre on Population Approaches for NCD Prevention, Nuffield Department of Population Health, University of Oxford, to provide the WHO Europe Member States with some guidance on achieving the SDG 3.4 (by 2030 reduce by one-third pre-mature mortality from NCDs through prevention and treatment and promote mental health and wellbeing). The values that the model uses to estimate the changes in mortality proceeds from peer-reviewed meta-analyses. Users must input three sets of data (age and sex distribution of the population; NCD mortality rates for a given year; risk factors) to then simulate different scenarios modifying one or more risk factors and obtain the predicted changes in the mortality of 24 NCDs.

In this case, for each country, we provided data on the i) average daily intake of salt (g/d) for the population and standard deviation, ii) age and sex distribution of the population, and, iii) mortality rates for each disease per year. This salt intake was calculated using Eq. 1, 2 and 3, previously discussed. The only risk factor we modified between scenarios was salt intake thus, for the other modifiable factors (i.e. physical activity, alcohol consumption) we assumed them stable. The result of our analysis was the number of deaths (due to several CVDs) averted per year if the targets defined for each counterfactual scenario were achieved (Table 3). The PRIME model can only compare a historical scenario with a counterfactual scenario and provide the predicted mortality for that same year thus, it cannot be used to predict future trends.

The Monte Carlo analysis was used to provide a realistic 95% CI around the number of deaths averted by using relative risk values to estimate the expected changes in mortality. We ran the model 5000 times to consider the uncertainty of the deterministic result [108].

3.4. Modelling Data Analysis On Cardiovascular Morbidity (Hypertension)

To estimate the impact on new hypertension cases we established a model that quantified PIF and prevented cases based on changes in salt content and food consumption.

The analysis was performed according to the presence of individual data (Portugal) or aggregated data (Spain and Italy).

In the case of Portugal, the individual dietary intake data was changed directly according to each scenario. For this, we used individual dietary intake data from the Portuguese national dietary survey (IAN-AF 2015-16).

In the case of aggregated (Italy and Spain) as a first step we simulated individual daily consumption from all food groups (x_{idf}) with the same sample size of the IAN-AF 2015-16 sample using the mean and standard deviation of each country, obtained from literature assuming Multivariate Normal Distribution, with the same covariance matrix as the Portuguese sample. Nevertheless, when the food group did not exist in the Portuguese data, we assumed the covariance was zero.

Then formula 2 was applied in order to obtain individual salt daily intake for each scenario (y_{id}). A bootstrapping was performed with 100 replicas to obtain a PIF bootstrap confidence interval by quantiles.

Estimating relative risk using a linear regression

Regarding the study used for the correlation between sodium and blood pressure levels, previous studies assessing the impact of salt policies[83,109] considered McGregor et al.[110] as the reference values for the association between SBP and sodium excretion. The report carried out a systematic review and meta-analysis of 34 trials (n = 3230) of at least 4 weeks of duration since it had been described that short-term experiments were not appropriate to estimate the long-term impact of reductions in salt intake. Results reported that a reduction in 100 mmol of 24h urinary sodium leads to a drop of 5.8 mmHg of the SBP. For the current study we decided to choose a more recent publication from Huang et al.[35] that included 133 studies (n=12197). They estimated that diminishing 50 mmol the 24h urinary sodium excretion resulted in a fall of the SBP by 1,1 mmHg. The duration of the interventions included, differed from <7 days up to >6 months, however, over 60% of total participants attended an intervention >30 days. Although, results from this study seem to indicate that length of the trial was not associated with the change in blood pressure, they did highlight that those interventions under <15 days could underestimate the impact of salt reduction in blood pressure.

We decided to choose the values from Huang et al.[35] because it includes a more recent estimate from more than half participants long-term interventions and additionally, the estimates are even more conservative than previous studies.

Huang et al.[35] reported that a reduction in 50 mmol of sodium (2.92g salt – change in salt excretion) leads to a reduction of 1.1 mmHg in SBP (change in SBP). We assumed a linear continuous regression between salt reduction and SBP levels.

(formula 4)

$$\boxed{\beta = change\ in\ salt\ excretion \times \frac{1}{change\ in\ SBP}}$$

The interquartile range (IQR) for SBP was 135 and 114mmHg based on a Portuguese study[111]. We considered these IQR to estimate the standard deviation (σ) based on the Cochrane Handbook[112].

(formula 5)

$$\boxed{\sigma = \frac{IQR}{1.35 * (1 - \sqrt{\varepsilon})}}$$

where ε refers to the correlation between SBP and dietary sodium intake which we considered 0.47 from a Chinese sample population[42].

Eq. 6 was used to calculate β* based on a study from Norris et al.[113]:

(formula 6)

$$\boxed{\beta^* = \frac{\pi}{\sqrt{(3)}\sigma}\beta}$$

Lastly, based on the previous calculations we estimated the relative risk (RR):

(formula 7)

$$\boxed{RR = \exp \beta^*}$$

Estimating baseline and counterfactual values

Based on the individual data of the IAN-AF 2015-16, we made changes to the salt content and food consumption of each food category for each different scenario.

Calculating the potential impact fraction for each scenario

The potential impact fraction (PIF) was calculated by changing the relative risks but keeping the exposure to that category constant. Based on the "RR shift" calculation defined by Barendregt and Veerman[114], we calculated the PIF:

(formula 8)

$$\boxed{\mathrm{PIF} = \frac{\sum_{c=1}^{n} p_c RR_c - \sum_{c=1}^{n} p_c RR_c^{*}}{\sum_{c=1}^{n} p_c RR_c}}$$

where RR and the RR* is the RR previously calculated and after the intervention, and *P* is the population distribution of exposure (in this case, the five scenarios of Table 2).

For the RR function log-linear function, we used:

(formula 9)

$$\boxed{RR = \exp(\log(RR) \text{ x } \boldsymbol{y_{id}})}$$

For Portugal, incidence of hypertension was already available and therefore we did not have to calculate it and we skipped formula 11 for this case. However, because we did not have incidence data available for Spain and Italy, we used the Portuguese incidence (47.3 per 1000 persons-years)[98] and prevalence (36%)[111] of hypertension to estimate the duration of hypertension as a diseases following the formula 11. Based on these calculations, the average duration of hypertension was 7.62 years based on the Portuguese data. Then, for Spain and Italy we estimated the incidence of hypertension (I) in these countries using the prevalence (P) from each country and the duration (d) previously calculated.

(formula 10)

$$\boxed{I = \frac{P}{d}}$$

To calculate the number of hypertension cases that would be prevented if the proposed targets were met (*n*), we used:

(formula 11)

$$\boxed{n = \mathrm{PIF} \text{ x } N \text{ x } I}$$

where N is the number of individuals in the population >18 years old (obtained from census data) and I is the incidence calculated in formula 10. The approximate number of cases prevented (*n*) will be calculated for each counterfactual scenario separately.

For the salt intake estimates of Portugal, we decided to choose the IAN-AF 2015-16[54] self-reported results, however, as previously mentioned, they can often be biased by errors. Thus, we performed a continuity correction using data from the IAN-AF 2015-16 subsample of 95 adults that was used to validate the new software used for the national survey.

(formula 12)

$$\boxed{\boldsymbol{y_{id\_corrected} = y_{id\_sodium\_excretion} - y_{id_{sodium\_selfreported}}}}$$

Based on the results from Goios et al.[54], estimated sodium intake from sodium excretion was 4,003mg while self-reporting data reported 3,489mg. Therefore, using formula 12, there was a misreporting of 514mg of sodium per day (1.285g of salt per day). Consequently, we added 1.285g/day to all salt intake baseline values for Portugal (see Table A8 in the Annex).

Results

1. Salt Content in Foods

Salt content changed according to either current policies or future policies proposed by the current study, baseline and expected salt content reductions due to reformulation can be seen in Table 4.

Out of the top five contributors to salt intake for each country, three were targeted by salt reduction policies in Spain, two in Portugal and none in Italy. Therefore, for those main contributors that were not targeted, we proposed future policies to reduce their salt content by -16%.

Three foods that were commonly targeted, either by current or future policies, in the three countries were (1) bread, (2) charcuterie and processed meats and, (3) cheeses. At baseline, the country with the highest content of salt for each food was (1) Spain for bread (2.08g salt/100g product), (2) for charcuterie and processed meats it was Portugal (4.38g salt/100g product), and (3) Italy for cheeses (1.3g salt/100g product). The Benchmark of salt in bread expected in 2020 varied from 1g of salt/100g product in Portugal to 1.31g of salt/100g product in Spain, while targets in Italy would remain in the middle (1.13g of salt/100g product). Charcuterie and other processed meats in Italy and Spain would have similar salt limits (2.5 and 2.58g of salt /100g product) while Portugal would be higher at 3.68g salt/100g product, even after a strong reduction of -16%. Cheeses in Spain would have the lowest salt content compared to Italy and Portugal (0.87g salt/100g product vs. 1.09, 1.63, respectively).

The main contributors that differed between countries and were considered for current food reformulation policies were a -10% salt content for ready-to-eat meals in Spain.

As previously mentioned, some of the strategies currently used in Spain and Portugal aimed to reduce salt content also on foods that are not the highest contributors to salt intake. In Spain the categories affected included sauces, canned soups, and salty snacks, with salt reformulation targets to reduce from -6.7% up to -16%. Similarly in Portugal, products targeted were pizzas, breakfast cereals, ready-to-eat meals and chips and other snacks, with policies ranging from -12% to -10%. Furthermore, in Portugal, although soups have been classified among the top five contributors to salt intake, salt policies have only targeted canned soups which itself is not among the top contributors.

Furthermore, the future policies we suggested would suppose a -16% reduction of the salt content of fresh meat for Spain, fish for Portugal and in Italy pizza, crackers and salty snacks, and other vegetables.

2. “Food Consumption Trend”

Table 4 shows estimates of the “food consumption trend” through changes in availability or sales for several food categories in 4 years. Overall, an increased availability/purchase of foods most contributing to salt was common for the three countries. Furthermore, some other similarities were found when comparing countries.

Higher availability/sales of charcuterie and other processed meats and, cheeses, occurred in the three countries. For charcuterie and other processed meats, the growth was stronger in Spain compared to Portugal and Italy (+51% vs. +3.02%, +11.50%). Availability/sales of cheeses were very similar for all countries with mildly higher values in Italy compared to Spain and Portugal (+10.94% vs. +10%, +10.83%).

A decrease in the availability/sales of bread was seen in all countries with a stronger intensity in Italy compared to Spain and Portugal (-5.39% vs. -5.00% and -2.86%).

Other categories more specific to each country followed different trends. In Spain, availability increased for ready-to-eat meals (+23.00%), sauces (+19.00%) and canned soups (+2%). While it lowered in categories such as salty snacks (-17.00%) and fresh meat (-2.00%).

In Portugal, sales of pizzas (+36.00%) and chips and other snacks (+10.00%) escalated. However, sales for breakfast cereals (-6.76%) and availability of fresh fish, dry or canned (-3.72%) lowered.

According to Italian data, sales of pizza, crackers and salty snacks reduced by -3.89%, and other vegetables (dry, processed and canned vegetables) increased by +6.44%.

Table 4. Baseline and projected values for salt content and “food consumption trend” (2016-2020) considered in the models for Spain, Portugal and Italy.

Country	**Food Category**	**Content** (g salt/100g product or % salt reduction)				**“Food Consumption Trend”**		
		Baseline	Policies		Expected	Average Annual Food Consumption/Availability (kg/pers/year)[94,95]		Trend of 4 years (%) (2016-2020)
		2016			2020	2016	2020	
SPAIN	Sausages and other processed meats	2.98[58]	AECOSAN 2017-2020[72]	-16%	2.56	8.23	12.39	+50.55%
	Sauces[+]	1.65[72]		-16%	1.39	2.60	3.09	+18.85%
	Canned soups	0.75[72]		-6.7%	0.70	99.80	101.60	+1.80%
	Ready-to-eat meals	1.36 [58]		-10%	1.17	13.70	16.85	+22.99%
	Salty snacks[+]	1.66 [72]		-13.8%	1.43	1.84	1.53	-16.85%
	Bread	2.08[115]	From 2022[73]	<1.66	1.66	34.65	32.78	-5.40%
	Cheese	1.04[59]	Proposed 2016-2020[106]	-16%	0.87	8.02	8.80	+9.73%
	Fresh meat	0.16[60]			0.13	37.11	36.20	-2.45%
PORTUGAL		2016	Policies		2020	Sale of Products (kg/year)[93]		Trend of 4 years (%) (2016-2020)[96*]
						2018	2020	
	Bread and “tostas”	1.33[53]	From 2021[81]	≤ 1g	1.00	-	-	-2.86%
	Canned soups	0.70[92]	From 2023[81]	<0.3g	0.30	-	-	-
	Ready-to-eat meals	-		<0.9g	0.90	-	-	-
	Pizzas	1.78[93]	2019-2022[81]	-10%	1.38	8,739,171	11,006,271	+36.00%
	Breakfast cereals	0.71[93]		-10%	0.60	16,503,001	14,633,223	-6.76%
	Chips and other snacks	1.25[93]		-12%	1.13	12,744,278	13,635,859	+10.08%
	Charcuterie and other processed meats	4.38[53]	Proposed 2016-2020[106,107]	-16%	3.68	-	-	+3.02%
	Fresh fish. dry or canned	1.29[53]			1.09	-	-	-3.72%
	Cheeses	1.94[53]			1.63	-	-	+10.83%
ITALY		2016	Policies		2020	Monthly Family Expenditure (€)[97†]		

						2016	2020	Trend of 4 years (%) (2016-2020)
	Bread and rolls	1.34[55]	Proposed 2016-2020[106]	-16%	1.13	23.02	21.78	-5.39%
	Processed meat	2.98[55]			2.5	23.21	25.88	+11.50%
	Pizza. crackers and salty snacks	1.54[55]			1.29	5.66	5.44	-3.89%
	Cheese	1.30[55]			1.09	29.17	32.36	+10.94%
	Other vegetables	0.97[55]			0.81	15.52	16.52	+6.44%

“Food consumption trend” refers to changes in availability or sales for the several food categories through time. In green, current policies, and in orange, future policies suggested by the current study. For Portugal, the changes of availability over the period of 2016-2020 was already provided by the food balance sheets for several foods (bread, charcuterie and other processed meats, fresh fish, dry or canned and, cheeses). Instead, for pizzas, breakfast cereals and chips and other snacks, based on sales data from 2018-2021, we estimated the change in a four year period. * Data was only available for the difference between the two years. General categories were considered: (1) cereal grains, (3) meat, (4) fish, (5) cheeses. The food consumption of soup was not estimated because of lack of data on this specific dish and its importance in the Portuguese culture. Thus, for the calculations we assumed the soup consumption was stable during this period of time. †The following categories were considered: (1) Bread; (2) charcuterie; (3) the average trend was calculated from the two categories separately (pizza; cracker and salty snacks); (4) cheese and dairy products; (5) dry, processed or canned vegetables.

3. Population Salt Intake

According to our results, policies currently implemented in Spain and Portugal could reduce salt intake by -11.1% and -11.2%, respectively, if they were achieved. Furthermore, if future policies were implemented tackling all the top five contributors to salt intake, salt could reduce even more to a maximum of -13.6% in the case of Portugal and -12.0% for Spain. However, scenario 3 shows that if no policies are applied, the food consumption/availability of the foods contributing to salt is likely to increase in the three countries by +12.4% in Spain, +0.1% in Portugal and +1.9% in Italy.

The combination of implementing salt reduction policies and considering the "food consumption trend", corresponding to scenario 4, would lower salt intake by -1.5% in Spain, -13.4% in Portugal and -11.2% in Italy. Furthermore, if the public health campaign of "1 pinch of salt less a day" was promoted, salt intake from scenario 4 could even reduce by an extra -5.7%, -6.9% and -8.5% for Spain, Portugal and Italy, as they follow.

In summary, scenario 5 shows the impact that the overall combination of these factors would lead to, with the strongest impact in Portugal with a total of -24.00%, intermediate in Italy with -17.7% and the weakest in Spain with -7.1%.

Additionally, in the Annex, table A8 describes how salt intake would change according to age and gender for each specific scenario.

Table 5. Salt intake at baseline and expected percentual changes according to each scenario for the three countries.

Country	**Scenario**	**Scenario**				
		1	**2**	**3**	**4**	**5**
Spain	Compared to baseline	-11.1%	-12.0%	+12.4%	-1.5%	-7.1%
	Compared to scenario 3				-12.4%	
	Compared to scenario 4					-5.7%
Portugal	Compared to baseline	-11.2%	-13.6%	+0.1%	-13.4%	-24.0%
	Compared to scenario 3				-13.5%	
	Compared to scenario 4					-6.9%
Italy	Compared to baseline		-11.8%	+1.9%	-11.2%	-17.7%
	Compared to scenario 3				-11.8%	
	Compared to scenario 4					-8.5%

4. Potential Impact Fraction and Prevention of New Hypertension Cases

Table 6 indicates how the incidence and cases of hypertension would be reduced for each scenario in each country. In countries where current policies are already implemented, the incidence of hypertension is expected to decrease strongly by -10.99% in Spain and -9.64% in Portugal, preventing 189,915 and 41,123 cases, respectively. Furthermore, the implementation of future policies that we proposed to target the main foods contributing to salt, would decrease the incidence by -8.39% in Italy (N=147,339) to -14.53% in Portugal (N=61,957).

If we did not take into account the salt reduction policies and only considered the "food consumption trend", scenario 3, both incidence and cases of hypertension would increase for all the countries. Spain would have the strongest impact worsening the incidence of hypertension by +14.68% and increasing 253,532 cases of hypertension per year. The significance would be lower in Portugal with a mild increase of +0.65% of the new cases and increasing 2,780 hypertension cases more, and in Italy with +0.10% and 16,777 cases more.

However, the negative outcomes of the previous scenario are compensated by the implementation of salt reformulation policies. This mitigation is stronger in Portugal with hypertension reducing by -14.04% (N=59,867) compared to Italy, -7.29% (N=128,131), and lowest in Spain, -1.38% (N=2,381). Lastly, the implementation of a public health policy suggested in scenario 5 would have a relevant fall in the incidence and cases of hypertension prevented per year. The Italian population would benefit the most, with a decrease in incidence of -37.35% (N=655,989). Spain would have a smaller change in the incidence of hypertension compared to Portugal (-7.41% vs. -20.23%) but because of the size of the Spanish population, Spain would prevent 128,023 cases of hypertension per year and Portugal 86,240.

Table 6. Impact in PIF and HT cases prevented by each scenario in the three countries.

Country	Scenario	PIF			Cases HT prevented		
		2,50%	**50%**	**97,5%**	**2,50%**	**50%**	**97,5%**
Spain	**Scenario 1**	10.85%	10.99%	11.18%	187,334.60	189,915.20	193,030.40
	Scenario 2	11.69%	11.85%	12.04%	201,932.40	204,735.30	207,972.50
	Scenario 3	-15.10%	-14.68%	-14.34%	-260,892.60	-253,532.20	-247,765.90
	Scenario 4	1.23%	1.38%	1.54%	21,218.80	2,381.90	26,516.60
	Scenario 5	7.20%	7.41%	7.66%	124,318.20	128,023.40	132,291.60
Portugal	**Scenario 1**	9.11%	9.64%	10.11%	38,846.40	41,123.30	43,100.80
	Scenario 2	13.92%	14.53%	15.11%	59,359.90	61,957.00	64,431.52
	Scenario 3	-0.80%	-0.65%	-0.05%	-3,424.84	-2,780,24	-2,104.10
	Scenario 4	13.46%	14.04%	14.64%	57,379.08	59,867.10	62,408.95
	Scenario 5	19.39%	20.23%	21.25%	82,679.94	86,240.47	90,589.15
Italy	**Scenario 1**						
	Scenario 2	8.27%	8.39%	8.49%	145,207.40	147,339.90	149,112.00
	Scenario 3	-1.00%	-0.10%	-0.09%	-17,624.91	-16,777.24	-15,816.52
	Scenario 4	7.15%	7.29%	7.40%	125,617.80	128,131.70	129,971.50
	Scenario 5	37.04%	37.35%	37.63%	650,537.40	655,989.10	660,926.10

5. Total Deaths and CVD Deaths

The impact of the five scenarios studied in this current study on CV mortality can be seen in Table 7 for Spain, Table 8 for Portugal and Table 9 for Italy. The PRIME methodology we used accounted only for changes in salt intake among specific risk factors correlated with NCDs. Furthermore, the model only considered the established association between salt and CV mortality, therefore for these specific results, the prevented total deaths correspond to prevented CV deaths.

Results indicate that current salt reformulation strategies currently enforced in Spain and Portugal could be effective at reducing total deaths by -1.55% in Spain (N= 3,155 deaths) and -1.33% in Portugal (N= 728 deaths). Implementing the future policies that we suggested in scenario 2 would even have a stronger impact, preventing from 4,442 deaths in Italy (-3.11% of total deaths, -4.48% of CV deaths) to 3,397 in Spain (-1.67% of total deaths, -4.80% of CV deaths). Percentual changes in diseases such as rheumatic heart disease or pulmonary embolism might seem stronger than for CHD and stroke. However, this is because the baseline deaths are quite low for these diseases but if we look at the absolute number of deaths prevented, the main CVDs (CHD, stroke and heart failure) figures are much higher than for pulmonary embolism and rheumatic heart disease.

The “food consumption trend” seems to indicate that all these Southern countries would increase their total deaths and CV deaths, especially those due to hypertensive diseases. Deaths due to CVD would increase by +5.18% for Spain (N= 3,671 deaths), +0.04% for Portugal (N= 9 deaths) and +0.72% for Italy (N=715 deaths). Similarly, to the previous results in Tables 5 and 6, the impact of the increasing “food consumption trend” of the main contributors to salt could be reduced by the implementation of policies considered in scenario 4. All countries would benefit from this scenario however, changes in Spain would be moderate, and CV deaths would decrease by -0.62% (N=439 deaths), compared to -4.29% (N= 4,250 deaths) for the Italian population. Aligned with the results from scenario 4, scenario 5 shows the most optimistic results with changes from -2.86% in CV deaths in Spain (N= 2,029 deaths) up to -6.88% in Portugal (N=1.536 deaths) and -6.69% in Italy (N=6,626 deaths).

Table 7. Deaths averted and change expected compared to baseline in Spain

SPAIN	**Baseline deaths**	**Scenario 1**		**Scenario 2**		**Scenario 3**		**Scenario 4**		**Scenario 5**	
		Deaths averted	**%**	**Deaths averted**	**%**	**Deaths averted**	**%**	**Deaths averted**	**%**	**Deaths averted**	**%**
Total Deaths	**-203,385**	3,155 (1,388–4,888)	**-1.55%**	3,397 (1,433–5,207)	**-1.67%**	-3,671 (-5,797– -1,496)	**1.80%**	439 (195–679)	**-0.22%**	2,029 (837–3,173)	**-1.00%**
<75	**-64,918**	677 (292–1,056)	-1.04%	730 (726–1,130)	-1.12%	-804 (-1,262–-335)	1.24%	86 (33–139)	-0.13%	432 (172–683)	-0.67%
Male	**-108,098**	1,433 (631–2,224)	-1.33%	1,542 (1,533–2,369)	-1.43%	-1,651 (-2,604– -671)	1.53%	203 (91–312)	-0.19%	922 (382–1,443)	-0.85%
Female	**-95,287**	1,723 (758–2,662)	-1.81%	1,855 (1,846–2,836)	-1.95%	-2,020 (-3,184– -825)	2.12%	237 (103–367)	-0.25%	1,107 (455–1,730)	-1.16%
Male <75	**-43,628**	488 (210–763)	-1.12%	527 (524–818)	-1.21%	-584 (-916– -245)	1.34%	60 (22–99)	-0.14%	311 (122–493)	-0.71%
Female <75	**-21,290**	189 (83–293)	-0.89%	203 (202–313)	-0.95%	-220 (-346– -91)	1.03%	26 (11–40)	-0.12%	121 (50–190)	-0.57%
CVDs	**-70,828**	3,155 (1,388–4,888)	**-4.46%**	3,397 (1,433–5,207)	**-4.80%**	-3,671 (-5,797– -1,496)	**5.18%**	439 (195–679)	**-0.62%**	2,029 (837–3,173)	**-2.86%**
Coronary Heart Disease	**-29,654**	726 (321–1,139)	-2.45%	782 (331–1,215)	-2.64%	-808 (-1,277–-326)	2.72%	109 (53–165)	-0.37%	469 (196–735)	-1.58%
Stroke	**-25,810**	655 (282–1,042)	-2.54%	706 (290–1,105)	-2.74%	-764 (-1,207–-319)	2.96%	85 (33–137)	-0.33%	418 (166–669)	-1.62%
Heart failure	**-7,596**	612 (265–989)	-8.11%	664 (275–1,055)	-8.74%	-710 (-1,158–-289)	9.35%	84 (36–135)	-1.11%	395 (158–637)	-5.20%
Aortic aneurysm	**-1,511**	60 (26–98)	-3.98%	65 (27–105)	-4.29%	-69 (-114– -28)	4.58%	8 (4–13)	-0.54%	39 (15–63)	-2.55%
Pulmonary embolism	**-914**	36 (11–70)	-3.96%	39 (12–75)	-4.27%	-41 (-81– -13)	4.49%	5 (1–10)	-0.54%	23 (7–45)	-2.53%
Rheumatic heart disease	**-379**	20 (5–40)	-5.21%	21 (6–42)	-5.62%	-22 (-45– -6)	5.91%	3 (1–5)	-0.71%	13 (3–26)	-3.33%
Hypertensive disease*	**-4,964**	1,042 (467–1,588)	-20.98%	1,120 (479–1,687)	-22.57%	-1,257 (-1,981– -513)	25.32%	145 (64–224)	-2.93%	673 (278–1,041)	-13.55%

Values reported correspond to mean (95% CI) calculated running the Monte Carlo analysis 5000 times. CVDs, Cardiovascular Diseases. *Hypertensive disease as a cause of death corresponds to I10-I15 according to ICD-11 including primary hypertension, hypertensive heart disease, hypertensive renal disease, hypertensive heart and renal disease and, secondary hypertension[116].

Table 8. Deaths averted and change expected compared to baseline in Portugal.

PORTUGAL	**Baseline deaths**	**Scenario 1**		**Scenario 2**		**Scenario 3**		**Scenario 4**		**Scenario 5**	
		Deaths averted	**%**	**Deaths averted**	**%**	**Deaths averted**	**%**	**Deaths averted**	**%**	**Deaths averted**	**%**
Total Deaths	**-54,745**	728 (320–1,148)	-1.33%	882 (381–1,371)	-1.61%	-9 (-14– -3)	0.02%	871 (373–1,361)	-1.59%	1,536 (663–2,359)	-2.81%
<75	**-17,633**	193 (84–302)	-1.09%	234 (100–363)	-1.33%	-4 (-6– -3)	0.02%	231 (99–362)	-1.31%	408 (175–629)	-2.31%
Male	**-27,979**	367 (161–578)	-1.31%	444 (192–688)	-1.59%	-4 (-8– -1)	0.02%	439 (189–686)	-1.57%	772 (335–1,187)	-2.76%
Female	**-26,766**	361 (159–572)	-1.35%	438 (189–680)	-1.64%	-4 (-6– -2)	0.02%	432 (184–676)	-1.62%	763 (329–1,179)	-2.85%
Male <75	**-11,744**	141 (60–221)	-1.20%	171 (73–265)	-1.45%	-4 (-5– -2)	0.03%	168 (72–264)	-1.43%	297 (127–459)	-2.53%
Female <75	**-5,889**	52 (23–82)	-0.89%	63 (27–98)	-1.08%	-1 (-1– 0)	0.01%	63 (27–98)	-1.06%	110 (47–171)	-1.88%
CVDs	**-22,329**	**728 (320–1,148)**	**-3.26%**	**882 (381–1,371)**	**-3.95%**	**-9 (-14– -3)**	**0.04%**	**871 (373–1,361)**	**-3.90%**	**1,536 (663–2,359)**	**-6.88%**
Coronary Heart Disease	**-7,366**	165 (74–260)	-2.24%	200 (87–310)	-2.71%	0 (-2– 3)	0.00%	197 (86–309)	-2.68%	348 (151–538)	-4.72%
Stroke	**-11,732**	258 (111–412)	-2.20%	314 (134–493)	-2.67%	-5 (-9– -2)	0.04%	310 (129–491)	-2.64%	550 (233–858)	-4.68%
Heart failure	**-1,827**	133 (58–216)	-7.30%	162 (66–260)	-8.85%	-1 (-2– -1)	0.08%	160 (67–257)	-8.74%	282 (119–445)	-15.45%
Aortic aneurysm	**-255**	10 (4–16)	-3.97%	12 (5–20)	-4.81%	0 (0–0)	0.04%	12 (5–20)	-4.76%	21 (9–35)	-8.40%
Pulmonary embolism	**-262**	9 (3–18)	-3.60%	11 (3–22)	-4.37%	0 (0–0)	0.04%	11 (3–22)	-4.32%	20 (6–38)	-7.68%
Rheumatic heart disease	**-49**	2 (1–4)	-3.96%	2 (1–5)	-4.81%	0 (0–0)	0.04%	2 (1–5)	-4.75%	4 (1–8)	-8.45%
Hypertensive disease*	**-838**	150 (66–233)	-17.87%	181 (79–278)	-21.58%	-2 (-3– -1)	27.30%	179 (77–281)	-21.32%	310 (133–471)	-37.04%

Values reported correspond to mean (95% CI) calculated running the Monte Carlo analysis 5000 times. CVDs, Cardiovascular Diseases. *Hypertensive disease as a cause of death corresponds to I10-I15 according to ICD-11 including primary hypertension, hypertensive heart disease, hypertensive renal disease, hypertensive heart and renal disease and, secondary hypertension[116].

Table 9. Deaths averted and change expected compared to baseline in Italy.

ITALY	**Baseline deaths**	**Scenario 1**		**Scenario 2**		**Scenario 3**		**Scenario 4**		**Scenario 5**	
		Deaths averted	**%**	**Deaths averted**	**%**	**Deaths averted**	**%**	**Deaths averted**	**%**	**Deaths averted**	**%**
Total Deaths	**-210,584**			4,442 (1,978–6,848)	**-2.11%**	**-715 (-1,144– -295)**	**0.34%**	4,250 (1,818–6,611)	**-2.02%**	**6,626 (2,893–10,314)**	**-3,15%**
<75	**-47,962**			861 (383–1,334)	-1.80%	-153 (-236– -70)	0.32%	824 (347–1,290)	-1.72%	1,290 (557–2,008)	-2,69%
Male	**-101,758**			2,377 (1,065–3,645)	-2.34%	-366 (-592– -143)	0.36%	2,275 (982–3,529)	-2.24%	3,537 (1,556–5,484)	-3,48%
Female	**-108,790**			2,065 (908–3,198)	-1.90%	-349 (-549– -153)	0.32%	1,975 (841–3,086)	-1.82%	3,089 (1,342–4,814)	-2,84%
Male <75	**-30,122**			642 (284–994)	-2.13%	-116 (-179– -54)	0.39%	614 (258–963)	-2.04%	962 (415–1,499)	-3,19%
Female <75	**-17,840**			219 (98–339)	-1.23%	-37 (-58– -16)	0.21%	210 (89–328)	-1.18%	328 (142–510)	-1,84%
CVDs	**-99,098**			**4,442 (1,978–6,848)**	**-4.48%**	**-715 (-1,144– -295)**	**0.72%**	**4,250 (1,818–6,611)**	**-4.29%**	**6,626 (2,893–10,314)**	**-6,69%**
Coronary Heart Disease	**-32,588**			1,390 (627–2,144)	-4.27%	-189 (-321– -59)	0.58%	1,331 (580–2,069)	-4.08%	2,068 (914–3,240)	-6,35%
Stroke	**-29,296**			1,246 (536–1,965)	-4.25%	-220 (-345– -100)	0.75%	1,191 (496–1,890)	-4.06%	1,873 (803–2,956)	-6,39%
Heart failure	**-58**			4 (2–6)	-6.69%	-1 (-1– 0)	1.11%	4 (2–6)	-6.40%	6 (2–9)	-10,01%
Aortic aneurysm†	**-8,078**			251 (106–409)	-3.11%	-42 (-69– -18)	0.52%	240 (100–386)	-2.97%	376 (161–604)	-4,66%
Pulmonary embolism†	**-4,224**			66 (20–127)	-1.57%	-11 (-21– -3)	0.26%	63 (18–120)	-1.50%	99 (30–190)	-2,36%
Rheumatic heart disease†	**-2,805**			40 (11–78)	-1.41%	-7 (-13– -2)	0.23%	38 (10–75)	-1.35%	60 (16–116)	-2,12%
Hypertensive disease*	**-22,049**			1,445 (652–2,219)	-6.55%	-246 (-388– -107)	1.12%	1,383 (594–2,129)	-6.27%	2,143 (937–3,283)	-9,72%

Values reported correspond to mean (95% CI) calculated running the Monte Carlo analysis 5000 times. CVDs, Cardiovascular Diseases. *Hypertensive disease as a cause of death corresponds to I10-I15 according to ICD-11 including primary hypertension, hypertensive heart disease, hypertensive renal disease, hypertensive heart and renal disease and, secondary hypertension. †Data for deaths due to aortic aneurysm, pulmonary embolism and rheumatic heart disease was not available thus, baseline values were calculated using Spanish data and making it proportional to the size of the Italian population[116].

Discussion

Our results suggest that the application of food reformulation policies in Southern European countries is not only effective but necessary for the prevention of NCDs and reduction of overall deaths due to CVDs. The “food consumption trend” of the main contributors to salt intake is increasing in Spain, Portugal and Italy, indicating that if no policies are applied, incidence of hypertension is expected to get higher. However, this situation can be still reverted in all three countries by implementing regulations (including current and future policies) that limit salt content on the food products contributing the most to population salt intake. An important consideration is that current policies implemented in Portugal would be sufficient to mitigate the impact of the increasing “food consumption trend”, despite of the additional benefit that could be obtained by further policies oriented to the top food contributors to salt intake. However, for Spain the current policies would not be sufficient.

Implementation of food policies alone (considering current policies and implementation of future policies suggested by the current study) without considering the “food consumption trend” could reduce hypertension incidence and CV deaths by -11.85% and -4.80% in Spain, -9.64% and -3.95% in Portugal and, -8.39% and -4.48% in Italy, respectively. If taking into account the changes in consumption according to the trend, the impact would be -1.38% PIF and -0.62% CV deaths in Spain, -14.04% PIF and -3.9% CV deaths in Portugal and, -7.29% PIF and -4.29% CV deaths in Italy. Lastly, the additional implementation of a public health campaign to reduce added salt would achieve a total reduction in new hypertension cases and deaths due CVD of -7.41% and -2.86% for Spain, -20.23% and -6.88% for Portugal and, -37.35% and -6.69% for Italy.

Studies conducted in other countries, such as Finland, corroborate the impact of how salt reformulation of food products can improve the population health. The Finnish population had a strong decrease of about -30% in sodium excretion between the 1970s and the early 2000s which was aligned with a drop of -10mmHg lower in blood pressure, although causality has not been confirmed. Furthermore, other CV outcomes were reduced such as stroke and coronary heart disease mortality by 75% and 80%, respectively [4,117]. Other modelling studies conducted in the United States and in Argentina indicated that the implementation of food reformulation policies (decreasing dietary salt intake by 3g/d, and -8% reduction of salt intake, respectively) could lead to substantial reductions of the total mortality (from -44,000 to -92,000 of total deaths for the US and -19,000 for Argentina) mainly through lower stroke and myocardial infarction mortality[118,119]. Goiana-da-Silva et al.[82] reported similar outcomes regarding the effectiveness of salt reformulation policies in Portugal. After assessing the impact of salt, sugar and trans-fat reformulation, they found that salt would have had the strongest impact in reducing NCD mortality.

As previously mentioned, WHO Member States have committed to reducing their salt intake by 30% in 2025 with the aim of achieving <5g/d[63]. Hendriksen et al.[67] assessed the impact of these two scenarios i) a reduction of 30% on salt intake among all population, and 2) salt intake being <5 g/day on cardiovascular health, among different European Countries. They reported that in Italy, 103,000 deaths would be averted per year in the first case and 163,300 for the second. And Spain would have prevented 59,100 and 97,400 deaths, respectively[67]. However, the research did not include the "food consumption trend" of the main food products contributing to salt intake.

Our research suggests that the availability/sales tendency must be taken into account since it might be increasing, and it will also help researchers model a better representation of the reality. Based on our results using a realistic scenario where the impact of policies is evaluated together with changes in consumption based on this trend, the objectives defined by the World Health Assembly of a 30% reduction, seem to be unattainable. Even with our most ambitious scenario that assumes effective reformulation, changes in food consumption and additionally a potential public health campaign to reduce "1 pinch of salt a day", would result in a decrease of -6.1%, -24.0% and -17,7% of the salt intake in Spain, Portugal and Italy, respectively, far from the WHO target.

Although these numbers are promising, they are unquestionably far from the targets defined. Instead, regarding the World Health Assembly target of reducing CV deaths and prevalence of hypertension by 25% in 2025. Our results suggest that the most optimistic scenario (scenario 5) could diminish the incidence of hypertension strongly by -6.17% in Spain, -20.23% in Portugal and -37.35% in Italy which might be closer to the WHO goals.

One aspect to take into consideration is that our current study only evaluated the impact of these strategies on a 4-year period, however, the World Health Assembly defined these targets in 2013 to be achieved by 2030. Therefore, achieving international goals to reduce the morbidity and mortality of CVD require timely and sustained policies because if applied too late, it is harder to reach the targets.

When considering how to apply future policies, legislative changes might be a better choice to consider. Mandatory regulations for salt reformulation have been described as more effective than voluntary agreements[120–122]. However, national policies should work together with the food production industry to facilitate consumer acceptance, a key factor for food reformulation policies as it can become a limitation [3,117,123]. For example, when reformulating cheeses to compensate the decrease in sodium, fat content has to be increased which represents an issue for consumers' acceptability[123]. The WHO highlights the importance of considering countries that have active food reformulation policies as examples for others since they can be easily adapted to other contexts[124]. Additionally, for example, we recognise that for cheeses, additional guidelines have to be established according to subgroups and regional production. However, lowering salt content has been possible in the UK where benchmarks have been established for cheese subgroups and other countries worldwide[125]. Similarly, although producing charcuterie with lower salt content is challenging, processed meat in Portugal has the highest salt content out of the three countries. Previous Spanish policies have already tackled to reduce 16% of salt content in this food category thus, reinforcing that this is possible[107].

Regarding the type of interventions, most research is focused on multiple *upstream* interventions (food reformulation, taxation, and food labelling) suggesting that the biggest changes would be achieved through the implementation of these. While *downstream* policies focused on individual changes (i.e. food labelling, health education, communication campaigns and promotion of healthy environments) are often thought to have less impact[122]. Some of these policies might include establishing benchmarks of salt content for products sold or prepared in canteens from settings such as hospitals, workplaces, or schools. However, these *downstream* strategies are not only effective at reducing national salt consumption, increasing knowledge of health risks, and changing behaviours related to salt consumption, but they are also recognised among WHO "Best Buys" to improve unhealthy diets[62,124,126].
The WHO recommends using comprehensive strategies that combine the two approaches to have a stronger impact on the salt intake of the population. Additionally, their guidelines also stress the importance of monitoring the population salt intake, salt content on foods and impact of salt reduction strategies, to evaluate future strategies[63,124].

The current study evaluated the impact of a public health campaign of "1 pinch of salt less a day" that we estimated could lead to a further decrease of the -5.9%, -6.9% and -8.5% of the salt intake in Spain, Portugal, and Italy, as they follow, compared to scenario 4. This initiative could be done through social marketing or promoted in specific settings at national level. For example, in the case of Portugal, soup is considered the second-highest contributor to salt intake and is part of the traditional Portuguese cuisine to have soup as the first dish. Furthermore, this product is mostly consumed "fresh" (not canned) at home, canteens or in restaurants. Therefore, policies do not intend to reduce consumption of soup, however, a policy could be proposed to reduce "1 pinch of salt less" when cooking or establishing salt content limits for soups in canteens of schools, workplaces, and hospitals.

Strengths and Limitations

The main strength of the current study relies on the fact that this is the first study to **1)** evaluate the impact of current food reformulation policies implemented in Spain and Portugal; **2)** assess the impact of specific policies on cardiovascular morbidity; **3)** consider the "food consumption trend" and **4)** consider the covariance between foods in their statistical models. Furthermore, it aims to fill the lack of guidance on public health policies for salt intake in Southern European countries.

Studies have been conducted in these countries to estimate the impact of policies after a salt target had been achieved (i.e. impact of the reduction of salt in bread in Portugal[83]) or assessing the impact of hypothetical overall salt reductions[67]. However, there is the need for more studies assessing the impact of regulations that target specific food categories. Additionally, previous research has mostly focused on estimating the weight on cardiovascular mortality but not morbidity (i.e. hypertension).
Another strength of this study is that we used individual consumption data from Portugal to simulate a more realistic consumption distribution for specific foods in the CV morbidity

model. We assumed that consumption distribution and the covariances between foods for Spain and Italy were the same as for Portugal because although it is not representative for these two countries, we believed it was better than using average population estimation.

The limitations of this study are mostly due to the weaknesses of comparing country estimates that have used different methodologies to obtain the necessary data of the current impact models. The salt intake was estimated from 24-hour urinary samples of large populations in Spain and Italy. In Portugal we had data from 24-h urinary sodium excretion from an IAN-AF 2015-16 subsample of 95 adults. Therefore, although the sample was small, we corrected for the potential bias on the self-reported estimates adjusting for the misreporting of the real sodium excreted.

Methodologies used to estimate the "food consumption trend" differed for each country, as previously mentioned. Two-point individual consumption data would have been the ideal method to estimate trends. However, since this data was not available for the countries, Household Budget Surveys (HBS) were an alternative preferred as opposed to the other sources. HBS were available for Spain and Italy but not for Portugal during the studied period. The strength of these two methods is that they are useful for inter-country comparability which is key for the aim of this study[127]. However, neither FBS nor HBS are a representation of the real consumption since no actual dietary intake is collected. Furthermore, although HBS are considered to be representative of available foods at family level (out-of-home food consumption was not accounted for most foods in Spain except for snacks, and for Italy it was unspecified if sales included it), the food categories considered were not standardised and we had to choose unclear categories for Italy (i.e. for processed meats, we chose the "salumi" category which only includes charcuterie, excluding other processed meats). Additionally, HBS in Spain and Italy differed since the latter indicated expenditure which does not only depend on the sales, but price of the food as well [97]. For Portugal we considered FBS for the main contributors to salt intake (i.e. bread, processed meats, cheeses and fish)[96] however, for specific categories (i.e. canned soups, snacks and chips) we used sales data from Nielsen IQ[93]. However, for Portugal we did not have available information from consumption/availability trend for canned soups and ready-to-eat meals (considered in polices) or for fresh vegetable soups (a main contributor of salt intake). Therefore, we assumed that the trend would be stable.

Food consumption of the main contributors to salt intake was assessed differently between countries. In Spain reported estimates were based on a 3-day food diary[61] however for main contributors of salt intake products identified differed from another study that had used a FFQ [128]. Unfortunately, because the food consumption data of the FFQ was not published, we lacked data and we decided to use the 3-day food diary study. For Portugal on two non-consecutive 24-h recalls[91] and Italy with a FFQ version more valid than the traditional ones[55]. Additionally, only in Portugal discretionary salt was estimated based on the individual consumption data (i.e. considering salt content in traditional recipes)[53], a rough approximation was available for Spain[51] and in Italy it was not assessed. Moreover, for those countries were current food policies targeted specific subcategories we considered the average salt content of all the subproducts and the average salt reduction proposed (i.e. in Spain different reductions were applied to each type of sauce, -16% of salt for mayonnaise, -5% for ketchup). However, because these foods are not important contributors of the diet, we believe they do not compromise the quality of the current study.

Regarding, the studies chosen for the prevalence of national hypertension, harmonisation of different factors was considered a priority, however, heterogeneity of methodologies was common. Among the main issues, we considered sampling strategy, sample size, ages of the participants and age representativeness of the sample to the age demography for that specific country. Considering these factors, ages included (Italy >18 years old vs. Spain >20 years old vs. Portugal 25-74 years old) and age representativeness (>75 years old: Italy 14% vs. Portugal 0%) were the biggest differences[27,99,129]. Another important aspect was the protocol used to measure blood pressure levels when assessing prevalence of hypertension. For Spain and Portugal, blood pressure was measured 3 times in 15 minutes in Spain and Portugal[99,129]. However, in Italy, hypertension was calculated retrospectively from health data of general practitioners, thus, number of measurements was not specified[27].

In our current study, we assessed the potential effectiveness of salt reduction interventions in the general population to ultimately reduce CVDs. The two models we used for the current study considered some disadvantages. In the case of CV mortality, the PRIME already provides estimates according to sex and age. However, the model used in the PRIME has a constraint because it only considers the impact of salt on CVD, ignoring the association with other NCDs such as cancer. Therefore, total deaths prevented will not be a representation of the reality. Furthermore, although "hypertensive diseases" as a cause of death has been defined by the ICD, we suspect that countries could have classified deaths for "hypertensive diseases" differently. Lastly, we lacked some mortality data from Italy that we had to estimate based on Spanish figures.

For the CV morbidity estimations, we were not able to take into account factors such as age, gender, or baseline blood pressure levels, factors that have been identified as strong modifiers of the changes in blood pressure[110]. Several studies even suggest that individuals with a blood pressure under the 75th percentile might not have a significant drop in SBP thus, suggesting that these policies should mostly target people with high blood pressure, correspondent to the 25th highest percentile of BP[41]. However, other epidemiologists do not agree with this assumption. Geoffrey Rose considered the example of the association between levels of blood pressure and coronary heart disease mortality to explain that "shifting the distribution curve of a single risk factor by a small amount in an entire population has a greater effect on death rates than does treating only people with high levels of that risk factor" [130]. According to Rose, the groups with lower levels of blood pressure a lower risk CHD mortality could also be an important target for policies since they represent a higher proportion of the population. Therefore, this would suggest that CV deaths could also lead to strong decreases in CV mortality also in the population with a lower blood pressure.

Another factor that we did not consider was food substitution in the "food consumption trend". For example, if consumption of bread decreases, the consumption of another food is likely to increase to compensate it. In this study we did not consider food substitution models although we recognise, it is an important factor when estimating the health impact of a policy[131].

Additionally, aligned with this weakness is that the period of this study considered partially coincided with the national lockdowns due to the Covid-19 pandemic. However, lockdowns only occurred during 2020 and thus, it only affected one quarter of our period of study. Although, the impact on dietary behaviours is still not clear[132,133], we recognise that they should be taken into account for future studies.

To estimate the preventable hypertension cases, we ideally needed the incidence for each country to have a better estimation of the new hypertension cases prevented. However, incidence was only available for Portugal. Therefore, for the estimates in the model of Portugal we used the incidence from a population-based cohort study conducted in the north of Portugal[98]. For Spain and Italy, we only had prevalence of hypertension values. Because from Portugal we had incidence[98] and prevalence[111] studies available, we decided to use them to calculate the duration of the disease. In this way, with the prevalence studies from each country (Spain and Italy) and the duration of disease calculated, we were able to estimate the incidence for that specific country. However, this strategy had some constraints. Despite the study assessing the incidence of hypertension in the Portuguese population is a population-based and included participants of wide age range, the age representativeness could be a limitation, since proportionally it included more elderly. This could result in a potential overestimation of the real hypertension incidence among the population[98] and in an overestimation of our final results. On the other side, the prevalence study from Portugal was conducted at a national level, using a different population age-range sample compared to the incidence study. Therefore, the duration of the disease calculated based on the Portuguese studies could have been affected by the limitations of the studies used and the difference in the population samples used for each.

Lastly, as mentioned in the methodology, this study assumed a study period from 2016 until 2020 to facilitate the modelling process and the comparability of the results between countries. For food reduction policies it does not seem to be a big issue since over the period of four years, there is time to assume a gradual reduction. However, the limitation we do acknowledge is that we considered baseline numbers in 2016 for some studies (i.e. prevalence and food consumption) that had been carried out some years before. Thus, baseline for some categories might be inaccurate since no other data was available. Although we recognise the difficulty of having all the ideal necessary data to complete a study among different countries, the current study provides useful information for stakeholders to rethink and guide future policies.

Considerations for Future Studies

In the current study, for each country, we only had one point measurement of individual consumption data from a national representative sample. Then, based on food availability indicators we estimated the "food consumption trend". For future studies, we believe that having at least two-point measurements of individual consumption data from national representative samples could improve the estimation of trends. Thus, highlighting the importance of having national consumption data at individual level using standardised methodologies and collected with reasonable periodicity.

Future modelling studies should try to distinguish between the effect that policies would have on normotensive and hypertensive individuals separately.

As previously mentioned, our study period was not fully affected by the Covid-19 pandemic. Evidence on the impact the Covid-19 pandemic had on dietary patterns is mixed and unclear. With some studies indicating an increased consumption of junk food [134] and others suggesting a higher adherence to a Mediterranean dietary pattern increased during this period.[132,133] Thus, we believe that future studies that take into account "food consumption trend" of foods, will need to evaluate the long-term dietary impact of the pandemic. Furthermore, statistical models, such as the one used in the current study, simplify the reality into scenarios that might not take into consideration aspects such as food safety/technical issues, substitution effect or pricing strategies when food reformulation occurs[43]. Therefore, we suggest that future studies try to take into consideration some of these factors that we were not able to consider.

A priority for prospective studies might be including modifiers such as age, gender, ethnicity and blood pressure levels at baseline. This will allow to draw conclusions on a more realistic approach and define for which population groups will the policies be more effective.

Conclusions

Salt reduction policies are an effective strategy to reduce the national salt intake among the population, prevent hypertension cases and CV deaths. However, if they do not target those foods that contribute more to sodium intake, they might be insufficient to achieve the targets defined.

More importantly this study might be the first one to consider the “food consumption trend” of the foods contributing to salt intake. An increasing tendency has been identified in Spain, Portugal and Italy, which is important to identify to have a realistic evaluation of the impact of salt policies. This highlights that if food policies are not applied (in the case of Italy) or not applied to the right food categories (for Spain), salt intake will not decrease and might even increase. Although the current study focused mostly on the impact of food reformulation of foods, we also evaluated a public health campaign promoting to cook with “1 pinch of salt less a day”. Our results indicated that this strategy might help additionally reduce the salt intake and ultimately reduce the future burden of CVDs.

Policy Implications

This study supports with strong evidence that national policies implemented already in countries like Spain and Portugal are effective. However, because consumption of high-salt foods is increasing, they may not be sufficient if they do not target those food categories contributing the most to salt intake.

Previous studies have not acknowledged the changes in availability and/or sales of the main contributors which might be crucial when assessing the health impact of food reformulation policies. Hence, the impact of future policies must be evaluated before their implementation to ensure that they will be the most cost-effective intervention. When establishing international targets such as the 30% reduction in salt intake defined by WHO, it is also important to evaluate if they are attainable.

Future policies should consider: 1) targeting main contributors to salt intake and either trying to settle agreements with the food industry or establishing mandatory regulations to limit salt content in foods; 2) establishing effective surveillance of salt content in foods and intake of the population and 3) applying comprehensive strategies that combine both *upwards* and *downwards* approaches.

References

1. World Health Organization. Time to deliver: report of the WHO Independent High-level Commission on Noncommunicable Diseases. [Internet]. Geneva; 2018 [cited 2021 Jan 9]. Available from: https://www.who.int/ncds/management/time-to-deliver/en/
2. Centers for Disease Control and Prevention. Cardiovascular Diseases [Internet]. CDC: Global Health Protection and Security. 2020 [cited 2021 Jan 9]. Available from: https://www.cdc.gov/globalhealth/healthprotection/ncd/cardiovascular-diseases.html
3. Hasenegger V, Rust P, König J, Purtscher AE, Erler J, Ekmekcioglu C. Main Sources, Socio-Demographic and Anthropometric Correlates of Salt Intake in Austria. Nutrients [Internet]. 2018 Mar 6 [cited 2022 Jun 12];10(3). Available from: /pmc/articles/PMC5872729/
4. Karppanen H, Mervaala E. Sodium intake and hypertension. Prog Cardiovasc Dis [Internet]. 2006 Sep [cited 2022 Jun 12];49(2):59–75. Available from: https://pubmed.ncbi.nlm.nih.gov/17046432/
5. GBD Compare | IHME Viz Hub [Internet]. [cited 2020 Dec 24]. Available from: https://vizhub.healthdata.org/gbd-compare/
6. Roth GA, Abate D, Abate KH, Abay SM, Abbafati C, Abbasi N, et al. Global, regional, and national age-sex-specific mortality for 282 causes of death in 195 countries and territories, 1980–2017: a systematic analysis for the Global Burden of Disease Study 2017. The Lancet [Internet]. 2018 Nov 10 [cited 2022 Sep 6];392(10159):1736–88. Available from: http://www.thelancet.com/article/S0140673618322037/fulltext
7. Roth GA, Mensah GA, Johnson CO, Addolorato G, Ammirati E, Baddour LM, et al. Global Burden of Cardiovascular Diseases and Risk Factors, 1990–2019: Update From the GBD 2019 Study. J Am Coll Cardiol. 2020 Dec 22;76(25):2982–3021.
8. James SL, Abate D, Abate KH, Abay SM, Abbafati C, Abbasi N, et al. Global, regional, and national incidence, prevalence, and years lived with disability for 354 Diseases and Injuries for 195 countries and territories, 1990-2017: A systematic analysis for the Global Burden of Disease Study 2017. The Lancet [Internet]. 2018 Nov 10 [cited 2022 Sep 6];392(10159):1789–858. Available from: http://www.thelancet.com/article/S0140673618322797/fulltext
9. Institute for Health Metrics and Evaluation (IHME). Global Burden of Disease 2019. University of Washington. 2022.
10. Cayuela L, Gómez Enjuto S, Olivares Martínez B, Rodríguez-Domínguez S, Cayuela A. Is the pace of decline in cardiovascular mortality decelerating in Spain? Revista Española de Cardiología (English Edition) [Internet]. 2021 Sep 1 [cited 2022 Aug 18];74(9):750–6. Available from: http://www.revespcardiol.org/en-is-pace-decline-in-cardiovascular-articulo-S1885585720304084
11. Direção Geral de Saúde, Institute for Health Metrics and and Evaluation. Portugal: The Nation’s Health 1990–2016: An overview of the Global Burden of Disease Study 2016 Results. [Internet]. Seattle, WA; 2018 Apr [cited 2021 Jan 9]. Available from: http://www.healthdata.org/sites/default/files/files/policy_report/2018/PolicyReport_GBD-Portugal_2018.pdf
12. Fornari C, Cortesi PA, Madotto F, Conti S, Crotti G, Mazzaglia G, et al. Cardiovascular diseases burden in Italy, 1990–2017: the Global Burden of Disease Study. Eur J Public Health [Internet]. 2020 Sep 1 [cited 2022 Aug 15];30(Supplement_5). Available from: https://academic.oup.com/eurpub/article/30/Supplement_5/ckaa165.811/5914360
13. Ihab R. Definition of hypertension and pressure goals during treatment (ESC-ESH Guidelines 2018). E-Journal of Cardiology Practice [Internet]. 2019 Aug 14 [cited 2022 Aug 19];17(18). Available from: https://www.escardio.org/Journals/E-Journal-of-

Cardiology-Practice/Volume-17/definition-of-hypertension-and-pressure-goals-during-treatment-esc-esh-guidelin

14. Stanaway JD, Afshin A, Gakidou E, Lim SS, Abate D, Abate KH, et al. Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks for 195 countries and territories, 1990-2017: A systematic analysis for the Global Burden of Disease Study 2017. The Lancet [Internet]. 2018 Nov 10 [cited 2022 Sep 7];392(10159):1923–94. Available from: http://www.thelancet.com/article/S0140673618322256/fulltext
15. Mahdi A, Armitage LC, Tarassenko L, Watkinson P. Estimated Prevalence of Hypertension and Undiagnosed Hypertension in a Large Inpatient Population: A Cross-sectional Observational Study. Am J Hypertens [Internet]. 2021 Sep 22 [cited 2022 Aug 19];34(9):963–72. Available from: https://academic.oup.com/ajh/article/34/9/963/6281066
16. Beaney T, Schutte AE, Tomaszewski M, Ariti C, Burrell LM, Castillo RR, et al. May Measurement Month 2017: an analysis of blood pressure screening results worldwide. Lancet Glob Health. 2018 Jul 1;6(7):e736–43.
17. Beaney T, Schutte AE, Stergiou GS, Borghi C, Burger D, Charchar F, et al. May Measurement Month 2019. Hypertension [Internet]. 2020 Aug 1 [cited 2022 Sep 7];76(2):333–41. Available from: https://www.ahajournals.org/doi/abs/10.1161/HYPERTENSIONAHA.120.14874
18. Banegas JR, Rodríguez-Artalejo F, de La Cruz Troca JJ, Guallar-Castillón P, del Rey Calero J. Blood pressure in Spain: distribution, awareness, control, and benefits of a reduction in average pressure. Hypertension [Internet]. 1998 [cited 2022 Sep 7];32(6):998–1002. Available from: https://pubmed.ncbi.nlm.nih.gov/9856963/
19. Banegas JR, Graciani A, de La Cruz-Troca JJ, León-Muñoz LM, Guallar-Castillón P, Coca A, et al. Achievement of cardiometabolic goals in aware hypertensive patients in Spain: a nationwide population-based study. Hypertension [Internet]. 2012 Oct [cited 2022 Sep 7];60(4):898–905. Available from: https://pubmed.ncbi.nlm.nih.gov/22949530/
20. Molinero A, Ruilope LM, Tous S, Fornos JA, Mera I, Andrés NF, et al. May Measurement Month 2017: an analysis of blood pressure screening in Spain—Europe. European Heart Journal Supplements [Internet]. 2019 Apr 1 [cited 2022 Sep 7];21(Supplement_D):D107–10. Available from: https://academic.oup.com/eurheartjsupp/article/21/Supplement_D/D107/5476839
21. Macedo ME, Lima MJ, Silva AO, Alcantara P, Ramalhinho V, Carmona J. Prevalence, awareness, treatment and control of hypertension in Portugal: the PAP study. J Hypertens [Internet]. 2005 [cited 2022 Sep 7];23(9):1661–6. Available from: https://pubmed.ncbi.nlm.nih.gov/16093910/
22. Polonia J, Martins L, Pinto F, Nazare J. Prevalence, awareness, treatment and control of hypertension and salt intake in Portugal: Changes over a decade the PHYSA study. J Hypertens [Internet]. 2014;32(6):1211–21. Available from: https://www.sphta.org.pt/files/physastudy_20150506_2.pdf
23. Barreto M, Gaio V, Antunes L, Rodrigues AP, Kislaya I, Santos AP, et al. Prevalence of Hypertension in Portugal: Results from the First National Health Examination Survey (2015). 9th European Public Health Conference (EPH), 9-12 November 2016 [Internet]. 2016 Nov 11 [cited 2021 Jan 19]; Available from: http://repositorio.insa.pt/handle/10400.18/4351
24. Tocci G, Muiesan ML, Parati G, Agabiti Rosei E, Ferri C, Virdis A, et al. Trends in Prevalence, Awareness, Treatment, and Control of Blood Pressure Recorded From 2004

to 2014 During World Hypertension Day in Italy. J Clin Hypertens. 2016 Jun 1;18(6):551–6.

25. Torlasco C, Faini A, Makil E, Ferri C, Borghi C, Veglio F, et al. Cardiovascular risk and hypertension control in Italy. Data from the 2015 World Hypertension Day. Int J Cardiol [Internet]. 2017 Sep 15 [cited 2022 Sep 7];243:529–32. Available from: http://www.internationaljournalofcardiology.com/article/S0167527317300062/fulltext
26. Torlasco C, Faini A, Makil E, Bilo G, Pengo M, Beaney T, et al. Nation-wide hypertension screening in Italy: data from May Measurements Month 2017—Europe. Eur Heart J Suppl [Internet]. 2019 Apr 1 [cited 2022 Jun 6];21(Suppl D):D66. Available from: /pmc/articles/PMC6479437/
27. Tocci G, Nati G, Cricelli C, Parretti D, Lapi F, Ferrucci A, et al. Prevalence and control of hypertension in the general practice in Italy: updated analysis of a large database. J Hum Hypertens [Internet]. 2017 Apr 1 [cited 2022 May 17];31(4):258–62. Available from: https://pubmed.ncbi.nlm.nih.gov/27629243/
28. European Food Safety Authority. Scientific Committee on Food Scientific Panel on Dietetic Products N and A. Tolerable Upper Intake Levels for Vitamins and Minerals. Opinion of the Scientific Panel on Dietetic Products, Nutrition ad Allergies on a Request from the Commission Related to the Tolerable Upper Intake Level of Sodium [Internet]. Parma; 2006 Feb [cited 2022 May 7]. Available from: https://www.efsa.europa.eu/sites/default/files/efsa_rep/blobserver_assets/ndatolerableuil.pdf
29. Ganong W. Review of Medical Physiology. 12th Edition. Los Altos, California: Lange Medical Publications; 1983.
30. Scientific Advisory Committee on Nutrition. Salt and Health. London; 2003.
31. Food and Nutrition Board. Dietary reference intakes for water, potassium, sodium, chloride and sulfate. 2004.
32. Strohm D, Boeing H, Leschik-Bonnet E, Arens-Azevêdo U, Bechthold A, Knorpp L. Salt intake in Germany, health consequences, and resulting recommendations for action. A scientific statement from the German Nutrition Society (DGE). Ernahrungs Umschau. 2016;63(03):62–70.
33. Intersalt: an international study of electrolyte excretion and blood pressure. Results for 24 hour urinary sodium and potassium excretion. Intersalt Cooperative Research Group. BMJ [Internet]. 1988 Jul 30 [cited 2022 Aug 6];297(6644):319–28. Available from: https://pubmed.ncbi.nlm.nih.gov/3416162/
34. Whelton PK. Body Weight, Sodium, Potassium, and Blood Pressure. The Journal of Clinical Hypertension [Internet]. 2015 Dec 1 [cited 2022 Aug 6];17(12):926. Available from: /pmc/articles/PMC8031981/
35. Huang L, Trieu K, Yoshimura S, Neal B, Woodward M, Campbell NRC, et al. Effect of dose and duration of reduction in dietary sodium on blood pressure levels: Systematic review and meta-analysis of randomised trials. Vol. 368, BMJ. BMJ Publishing Group; 2020.
36. Filippini T, Malavolti M, Whelton PK, Vinceti M. Sodium Intake and Risk of Hypertension: A Systematic Review and Dose–Response Meta-analysis of Observational Cohort Studies. Curr Hypertens Rep [Internet]. 2022 May 1 [cited 2022 Sep 8];24(5):133–44. Available from: https://link.springer.com/article/10.1007/s11906-022-01182-9
37. Strazzullo P, D’Elia L, Kandala NB, Cappuccio FP. Salt intake, stroke, and cardiovascular disease: Meta-analysis of prospective studies. BMJ (Online). 2009 Nov 25;339(7733):1296.

38. Eckel RH, Jakicic JM, Ard JD, de Jesus JM, Houston Miller N, Hubbard VS, et al. 2013 AHA/ACC guideline on lifestyle management to reduce cardiovascular risk: A report of the American College of cardiology/American Heart Association task force on practice guidelines. Circulation [Internet]. 2014 Jun 24 [cited 2022 Sep 8];129(25 SUPPL. 1):76–99. Available from: https://www.ahajournals.org/doi/abs/10.1161/01.cir.0000437740.48606.d1
39. Lennon SL, DellaValle DM, Rodder SG, Prest M, Sinley RC, Hoy MK, et al. 2015 Evidence Analysis Library Evidence-Based Nutrition Practice Guideline for the Management of Hypertension in Adults. J Acad Nutr Diet [Internet]. 2017 Sep 1 [cited 2022 Sep 8];117(9):1445-1458.e17. Available from: http://www.jandonline.org/article/S2212267217303489/fulltext
40. Sacks FM, Svetkey LP, Vollmer WM, Appel LJ, Bray GA, Harsha D, et al. Effects on blood pressure of reduced dietary sodium and the Dietary Approaches to Stop Hypertension (DASH) diet. DASH-Sodium Collaborative Research Group. N Engl J Med [Internet]. 2001 Jan 4 [cited 2022 Sep 8];344(1):3–10. Available from: https://pubmed.ncbi.nlm.nih.gov/11136953/
41. Graudal N, Hubeck-Graudal T, Jürgens G, Taylor RS. Dose-response relation between dietary sodium and blood pressure: a meta-regression analysis of 133 randomized controlled trials. Am J Clin Nutr [Internet]. 2019 May 1 [cited 2022 Aug 6];109(5):1273–8. Available from: https://academic.oup.com/ajcn/article/109/5/1273/5480600
42. Zhao Q, Gu D, Chen J, Bazzano LA, Rao DC, Hixson JE, et al. Correlation between blood pressure responses to dietary sodium and potassium intervention in a Chinese population. Am J Hypertens [Internet]. 2009 Dec [cited 2022 Jun 10];22(12):1281–6. Available from: https://pubmed.ncbi.nlm.nih.gov/19763120/
43. Afshin A, Sur PJ, Fay KA, Cornaby L, Ferrara G, Salama JS, et al. Health effects of dietary risks in 195 countries, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. The Lancet [Internet]. 2019 May 11 [cited 2022 Sep 8];393(10184):1958–72. Available from: http://www.thelancet.com/article/S0140673619300418/fulltext
44. Brussaard J, Löwik M, Steingrímsdóttir L, Møller A, Kearney J, de Henauw S, et al. A European food consumption survey method--conclusions and recommendations. Eur J Clin Nutr [Internet]. 2002 [cited 2022 May 17];56 Suppl 2:S89–94. Available from: https://pubmed.ncbi.nlm.nih.gov/12082521/
45. Natarajan L, Pu M, Fan J, Levine RA, Patterson RE, Thomson CA, et al. Measurement Error of Dietary Self-Report in Intervention Trials. Am J Epidemiol [Internet]. 2010 Oct 1 [cited 2022 Aug 5];172(7):819–27. Available from: https://academic.oup.com/aje/article/172/7/819/88050
46. Lucko AM, Doktorchik C, Woodward M, Cogswell M, Neal B, Rabi D, et al. Percentage of ingested sodium excreted in 24-hour urine collections: A systematic review and meta-analysis. The Journal of Clinical Hypertension [Internet]. 2018 Sep 1 [cited 2022 Aug 5];20(9):1220–9. Available from: https://onlinelibrary.wiley.com/doi/full/10.1111/jch.13353
47. World Health Organization (WHO). Mapping salt reduction initiatives in the WHO European Region. Copenhagen; 2013.
48. World Health Organization. Reducing salt intake in populations : report of a WHO forum and technical meeting. Paris; 2006 Oct.
49. European Comission. Health Promotion Knowledge Gateway. Defining dietary salt and sodium - overview of salt intake in adults across European countries [Internet]. Vol. 2. BioMed Central; 2021 [cited 2022 Sep 8]. Available from:

https://knowledge4policy.ec.europa.eu/health-promotion-knowledge-gateway/defining-dietary-salt-sodium-overview-adults-4a_en

50. Ortega RM, López-Sobaler AM, Ballesteros JM, Pérez-Farinós N, Rodríguez-Rodríguez E, Aparicio A, et al. Estimation of salt intake by 24 h urinary sodium excretion in a representative sample of Spanish adults. Br J Nutr [Internet]. 2011 Mar 14 [cited 2022 May 7];105(5):787–94. Available from: https://pubmed.ncbi.nlm.nih.gov/20969815/
51. Ministerio de Sanidad y Politica Social, Agencia Española de Seguridad Alimentaria y Nutrición. Plan de reducción del consumo de sal. Menos SAL es más SALud. Jornadas de debate [Internet]. La Granja de San Idelfonso ; 2009 Nov [cited 2022 May 21]. Available from: http://eurocarne.com/daal/a1/informes/a2/aesan-reduccion-sal.pdf
52. Partearroyo T, Samaniego-vaesken MDL, Ruiz E. Sodium Intake from Foods Exceeds Recommended Limits in the Spanish Population : The ANIBES Study. Nutrients [Internet]. 2019;11(2451):1–17. Available from: 10.3390/nu11102451
53. Lopes C, Torres D, Oliveira A, Severo M, Alarcão V, Guiomar S, et al. Inquérito Alimentar Nacional e de Atividade Física (IAN-AF 2015-2016): Relatório de resultados [Internet]. Porto; 2017 [cited 2021 Jan 9]. Available from: https://ian-af.up.pt/sites/default/files/IAN-AF%20Relat%C3%B3rio%20Resultados_0.pdf
54. Goios ACL, Severo M, Lloyd AJ, Magalhães VPL, Lopes C, Torres DPM. Validation of a new software eAT24 used to assess dietary intake in the adult Portuguese population. Public Health Nutr [Internet]. 2020;23(17):3093–103. Available from: https://www-cambridge-org.sire.ub.edu/core/journals/public-health-nutrition/article/validation-of-a-new-software-eat24-used-to-assess-dietary-intake-in-the-adult-portuguese-population/214AE0774CAD55C4E49B286A39342017
55. Malavolti M, Naska A, Fairweather-Tait SJ, Malagoli C, Vescovi L, Marchesi C, et al. Sodium and potassium content of foods consumed in an italian population and the impact of adherence to a mediterranean diet on their intake. Nutrients [Internet]. 2021 Aug 1 [cited 2022 May 17];13(8):2681. Available from: /pmc/articles/PMC8401684/
56. Donfrancesco C, lo Noce C, Russo O, Minutoli D, di Lonardo A, Profumo E, et al. Trend of salt intake measured by 24-h urine collection in the Italian adult population between the 2008 and 2018 CUORE project surveys. Nutrition, Metabolism and Cardiovascular Diseases. 2021 Mar 10;31(3):802–13.
57. Brown IJ, Tzoulaki I, Candeias V, Elliott P. Salt intakes around the world: implications for public health. Int J Epidemiol [Internet]. 2009 Jun 1 [cited 2022 May 14];38(3):791–813. Available from: https://academic.oup.com/ije/article/38/3/791/684827
58. Ministerio de Consumo, Agencia Española de Seguridad Alimentaria y Nutrición. Informe del Contenido en Sal en los Alimentos 2019 [Internet]. 2021 Aug [cited 2022 Apr 10]. Available from: https://www.aesan.gob.es/AECOSAN/docs/documentos/nutricion/INFORME_reducion_sal_OMS_PLAN_NAOS.pdf
59. Agencia Española de Consumo y Seguridad Alimentaria y Nutrición. Contenido de sal de los alimentos en España. 2012 [Internet]. Madrid; 2015 [cited 2022 May 7]. Available from: https://www.aesan.gob.es/AECOSAN/docs/documentos/nutricion/estudio_contenido_sal_alimentos.pdf
60. Moreiras O, Carbajal Á, Cabrera L, Cuadrada C. Tablas de Composición de Alimentos. Ediciones. 2013.
61. Partearroyo T, Lourdes D, Ruiz E. Current Food Consumption amongst the Spanish ANIBES Study Population. Nutrients. 2019;11(2663):1–15.

62. World Health Organization. Tackling NCDs: 'Best buys' and other recommended interventions for the prevention and control of noncommunicable diseases [Internet]. Geneva; 2017 [cited 2021 Jan 9]. Available from: https://apps.who.int/iris/bitstream/handle/10665/259232/WHO-NMH-NVI-17.9-eng.pdf?sequence=1&isAllowed=y
63. World Health Assembly. Follow-up to the Political Declaration of the High-level Meeting of the General Assembly on the Prevention and Control of Non-communicable Diseases [Internet]. 2013 May [cited 2022 Aug 6]. Available from: https://apps.who.int/gb/ebwha/pdf_files/WHA66/A66_R10-en.pdf?ua=1
64. Grosso G, Mateo A, Rangelov N, Buzeti T, Birt C. Nutrition in the context of the Sustainable Development Goals. Eur J Public Health. 2020 Mar 1;30(Suppl 1):I19–23.
65. Institute for European Environmental Policy. Europe Sustainable Development Report 2020. Performance of European countries against the SDGs [Internet]. 2020 [cited 2021 Jan 20]. Available from: https://eu-dashboards.sdgindex.org/chapters/part-1-performance-of-european-countries-against-the-sdgs
66. Breda J, Allen LN, Tibet B, Erguder T, Karabulut E, Yildirim HH, et al. Estimating the impact of achieving Turkey's non-communicable disease policy targets: A macro-simulation modelling study. The Lancet Regional Health - Europe [Internet]. 2021 Feb 1 [cited 2022 May 14];1. Available from: /pmc/articles/PMC8063152/
67. Hendriksen MAH, van Raaij JMA, Geleijnse JM, Breda J, Boshuizen HC. Health Gain by Salt Reduction in Europe: A Modelling Study. 2015;
68. European Commission. Implementation of the EU Salt Reduction Framework - Results of Member States survey [Internet]. Luxembourg; 2012 [cited 2021 Jan 18]. Available from: https://ec.europa.eu/health/sites/health/files/nutrition_physical_activity/docs/salt_report_en.pdf
69. Ministerio de Sanidad y Consumo, Agencia Española de Seguridad alimentaria. Convenio De Colaboración Entre El Ministerio De Sanidad Y Consumo Y La Confederación Española De Organizaciones De Panadería (Ceopan) [Internet]. Madrid; 2005 Feb [cited 2022 May 21]. Available from: https://www.aesan.gob.es/AECOSAN/docs/documentos/nutricion/CONVENIO_con_CEOPAN.pdf
70. Agencia Española de Seguridad Alimentaria y Nutrición. Reformulación del pan [Internet]. [cited 2022 May 21]. Available from: https://www.aesan.gob.es/AECOSAN/web/nutricion/subseccion/reformulacion_pan.htm
71. Pérez Farinós N, Santos Sanz S, Dal Re M, Yusta Boyo M. Salt content in bread in Spain, 2014. Nutr Hosp. 2018;35:650–4.
72. Agencia Española de Seguridad Alimentaria y Nutrición. PLAN de colaboración para la mejora de la composición de los alimentos y bebidas y otras medidas [Internet]. 2020 [cited 2022 May 17]. Available from: https://www.aesan.gob.es/AECOSAN/docs/documentos/nutricion/PLAN_COLABORACION_2020.pdf
73. Boletín Oficial Del Estado. Real Decreto 308/2019, de 26 de abril, por el que se aprueba la norma de calidad para el pan. [Internet]. 113 May 11, 2019. Available from: https://www.boe.es/boe/dias/2019/05/11/pdfs/BOE-A-2019-6994.pdf
74. Administração Regional de Saúde do Centro. Estratégia MINORSAL.SAÚDE [Internet]. 2014. Available from: https://www.arscentro.min-saude.pt/SaudePublica/Programas/Documents/minorsal Dezembro de 2014 ARS.pdf

75. Direção Geral de Saúde, Instituto Nacional de Saúde Dr Ricardo Jorge, Associações dos Industriais da Panificação Pastelaria e Similares. Guia para a atribuição do Selo Pão “Menos sal, mesmo sabor” [Internet]. 2018. Available from: https://www.sns.gov.pt/wp-content/uploads/2018/04/selo_excelencia_pao_com_menos_sal_regulamento.pdf
76. Pimentel J, Morais A, Cordeiro E, Pires G, Carvalho L. Plano Regional De Saúde Do Centro 2018-2020 [Internet]. Coimbra; 2018 [cited 2022 May 21]. Available from: https://www.arscentro.min-saude.pt/wp-content/uploads/sites/6/2020/04/Plano-Regional-Saude-2018-2020.pdf
77. Assembleia da República. Lei n.º 75/2009. Portugal: Diário da República n.º 155/2009, Série I de 2009-08-12; 2009 p. 5225–6.
78. Graça P, Gregório M. A construção do programa nacional para a promoção da alimentação saudável: aspectos conceptuais, linhas estratégicas e desafios iniciais. . Revista Nutrícias. 2013;18:6–9.
79. Secretaria-Geral do Ministério da Saúde. Protocolo de Colaboração entre a Direção-Geral da Saúde, o Instituto Nacional de Saúde Doutor Ricardo Jorge, I.P., a Associação dos Industriais de Panificação, Pastelaria e Similares de Lisboa, a Associação dos Industriais de Panificação, Pastelaria e Similares do Norte e a Associação dos Industriais de Panificação, Pastelaria e Similares. Lisboa, Portugal; 2017.
80. Direção Geral de Saúde. Estratégia Integrada para a Promoção da Alimentação Saudável (EIPAS) [Internet]. [cited 2021 Jan 9]. Available from: https://eipas.pt/
81. Direção Geral de Saúde. Programa Nacional para a Promoção da Alimentação Saudável [Internet]. Lisboa; 2019. Available from: https://alimentacaosaudavel.dgs.pt/alimentacao-em-numeros/relatorios-anuais-pnpas/
82. Goiana-Da-Silva F, Cruz-e-Silva D, Allen L, Gregório MJ, Severo M, Nogueira PJ, et al. Modelling impacts of food industry co-regulation on noncommunicable disease mortality, Portugal. Bull World Health Organ [Internet]. 2019 Jul 1 [cited 2021 Jan 18];97(7):450–9. Available from: http://www.who.int/bulletin/volumes/97/7/18-220566/en/
83. Instituto Nacional de Saúde Doutor Ricardo Jorge. Reduction of salt (sodium) in bread and its contribution to the decrease of blood pressure in Portugal: Health Impact Assessment pilot study-Final report [Internet]. Lisbon (Portugal); 2020 [cited 2022 May 20]. Available from: www.insa.pt
84. Gazzetta Ufficiale della Repubblica Italiana. Decreto del Presidente del Consiglio dei Ministri. Documento programmatico “Guadagnare salute”. [Internet]. 119 May 22, 2007. Available from: https://www.gazzettaufficiale.it/eli/id/2007/05/22/07A04385/sg
85. Ministero della Salute. Azioni e progetti del Ministero sul consumo di sale [Internet]. 2018 [cited 2022 May 19]. Available from: https://www.salute.gov.it/portale/temi/p2_6.jsp?lingua=italiano&id=4950&area=stiliVita&menu=alimentazione
86. European Commission. Defining dietary salt and sodium - examples of implemented policies addressing salt reduction | Knowledge for policy [Internet]. [cited 2022 May 21]. Available from: https://knowledge4policy.ec.europa.eu/health-promotion-knowledge-gateway/defining-dietary-salt-sodium-table-6_en
87. Strazzullo P, Cairella G, Campanozzi A, Carcea M, Galeone D, Galletti F, et al. Population based strategy for dietary salt intake reduction: Italian initiatives in the European framework. Nutrition, Metabolism and Cardiovascular Diseases. 2012 Mar;22(3):161–6.

88. Azienda Unità Sanitaria Locale di Modena. Campagna regionale - Pane Menosale - Più salute con meno sale [Internet]. 2021 [cited 2022 Jun 4]. Available from: https://www.ausl.mo.it/dsp/panemenosale
89. Mercasa. Alimentación En España Producción, Industria, Distribución Y Consumo 23ª Edición. 2020/2021 [Internet]. 2020 [cited 2022 Jun 24]. Available from: https://www.mercasa.es/wp-content/uploads/2022/03/AEE_2020_web.pdf
90. Agencia Española de Seguridad Alimentaria y Nutrición. Evaluación Intermedia De Los Acuerdos De Reducción Del Contenido En Nutrientes Seleccionados (Azúcar, Sal Y Grasas) Del Plan De Colaboración Para La Mejora De La Composición De Los Alimentos Y Bebidas Y Otras Medidas 2020. 2020.
91. Lopes C, Torres D, Oliveira A, Severo M, Alarcão V, Guiomar SJ, et al. Inquérito Alimentar Nacional e de Atividade Física, IAN-AF 2015- 2016: Relatório metodológico. [Internet]. 2017 [cited 2022 Jun 6]. Available from: https://ian-af.up.pt/sites/default/files/IAN-AF%20Relatorio%20Metodol%C3%B3gico.pdf
92. Cardoso S, Pinho O, Moreira P, Pena MJ, Alves A, Moreira JL, et al. Salt content in pre-packaged foods available in Portuguese market. Food Control. 2019 Dec 1;106:106670.
93. Ministério da Saúde. Direção-Geral da Saúde. Redução Do Teor De Sal E Açúcar Nos Alimentos | Relatório Do Progresso Da Reformulação Dos Produtos Alimentares Em Portugal 2018-2021. Lisboa; 2022 Feb.
94. Ministerio de Agricultura Pesca y Alimentación. Informe del Consumo Alimentario en España 2020. Madrid; 2021.
95. Ministerio de Agricultura Pesca y Alimentación. Informe del consumo de alimentación en España 2016 [Internet]. Madrid; 2017 Apr [cited 2022 May 7]. Available from: www.mapama.gob.es
96. Instituto Nacional de Estatística. Balança alimentar portuguesa : 2020. Lisboa; 2021.
97. Istituto Nazionale di Statistica. Spese per consumi: Voce di spesa (ECoicop) [Internet]. [cited 2022 Jun 6]. Available from: http://dati.istat.it
98. Pereira M, Lunet N, Paulo C, Severo M, Azevedo A, Barros H. Incidence of hypertension in a prospective cohort study of adults from Porto, Portugal. BMC Cardiovasc Disord [Internet]. 2012;12:114. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3529102/
99. Instituto Nacional de Saúde Doutor Ricardo Jorge. 1º Inquérito Nacional de Saúde com Exame Físico (INSEF 2015): relatório metodológico. [Internet]. Lisboa; 2016 [cited 2022 Jun 6]. Available from: http://repositorio.insa.pt/bitstream/10400.18/3832/3/1_INSEF_relatorio_metodologico.pdf
100. Instituto Nacional de Estatística. Censos 2011 Resultados Definitivos - Portugal. Lisboa; 2012.
101. Istituto Nazionale di Statistica. Popolazione residente al 1° gennaio: Per fascia di età [Internet]. ISTAT. [cited 2022 Jun 10]. Available from: http://dati.istat.it
102. Instituto Nacional de Estadística. Población residente por fecha, sexo y edad [Internet]. INE. [cited 2022 Jun 10]. Available from: https://www.ine.es/
103. Instituto Nacional de Estatística. Causas de Morte: 2017 [Internet]. 2019 [cited 2022 Jun 10]. Available from: https://www.ine.pt/xurl/pub/358633033
104. Istituto Nazionale di Statistica. Mortalità per causa del decesso nel periodo gennaio-giugno 2020 [Internet]. 2022 Apr [cited 2022 Jun 10]. Available from: https://www.istat.it/
105. Instituto Nacional de Estadística. Causa básica de defunción [Internet]. INE. [cited 2022 Jun 10]. Available from: https://www.ine.es/

106. High Level Group on Nutrition and Physical Activity - European Commission. Survey on Members States' Implementation of the EU Salt Reduction Framework [Internet]. 2014 [cited 2022 May 28]. Available from: https://www.aesan.gob.es/AECOSAN/docs/documentos/nutricion/observatorio/encuesta_estados_miembros_sal.pdf
107. Agencia Española de Seguridad Alimentaria y Nutrición. Plan 2014 de reducción de sal y grasa en los derivados cárnicos elaborados por los carniceros y charcuteros artesanales. Aecosan [Internet]. 2014 Jul;4–5. Available from: https://www.aesan.gob.es/AECOSAN/docs/documentos/publicaciones/aecosanoticias/AECOSANoticias_37.pdf
108. World Health Organization Regional Office Europe. NCD PRIME. Modelling the impact of national policies on noncommunicable disease (NCD) mortality using PRIME: a policy scenario modelling tool [Internet]. Denmark; 2019 [cited 2021 Jan 23]. Available from: https://www.euro.who.int/__data/assets/pdf_file/0014/411251/PRIME-a-policy-scenario-modelling-tool.pdf
109. Scarborough P, Harrington RA, Mizdrak A, Zhou LM, Doherty A. The Preventable Risk Integrated ModEl and Its Use to Estimate the Health Impact of Public Health Policy Scenarios. Scientifica (Cairo) [Internet]. 2014 [cited 2021 Jan 23];2014:1–21. Available from: /pmc/articles/PMC4195430/?report=abstract
110. He FJ, Li J, MacGregor GA. Effect of longer term modest salt reduction on blood pressure: Cochrane systematic review and meta-analysis of randomised trials. BMJ (Online) [Internet]. 2013;346(7903). Available from: https://pubmed.ncbi.nlm.nih.gov/23558162/
111. Instituto Nacional de Saúde Doutor Ricardo Jorge. 1o Inquérito Nacional de Saúde com Exame Físico (INSEF 2015): Estado de Saúde. Lisboa; 2016.
112. Higgins J, Green S. Cochrane Handbook for Systematic Reviews of Interventions: . Wiley Online Library; 2008.
113. Norris CM, Ghali WA, Saunders LD, Brant R, Galbraith D, Faris P, et al. Ordinal regression model and the linear regression model were superior to the logistic regression models. J Clin Epidemiol. 2006 May 1;59(5):448–56.
114. Barendregt JJ, Veerman JL. Categorical versus continuous risk factors and the calculation of potential impact fractions. J Epidemiol Community Health (1978) [Internet]. 2010 Mar [cited 2022 Aug 15];64(3):209–12. Available from: https://pubmed.ncbi.nlm.nih.gov/19692711/
115. Pérez-Farinós N, Santos-Sanz S, Dal-Re MÁ, Yusta-Boyo MJ, Robledo T, Castrodeza J-J, et al. Cantidad de sal en el pan en España, 2014. Nutr Hosp [Internet]. 2018 [cited 2022 Dec 7];35(3):650–4. Available from: https://scielo.isciii.es/scielo.php?script=sci_arttext&pid=S0212-16112018000300650&lng=es&nrm=iso&tlng=en
116. World Health Organization. International Classification of Diseases 11th Revision [Internet]. [cited 2022 Sep 12]. Available from: https://icd.who.int/en
117. Laatikainen T, Pietinen P, Valsta L, Sundvall J, Reinivuo H, Tuomilehto J. Sodium in the Finnish diet: 20-year trends in urinary sodium excretion among the adult population. European Journal of Clinical Nutrition 2006 60:8 [Internet]. 2006 Feb 15 [cited 2022 Jun 12];60(8):965–70. Available from: https://www.nature.com/articles/1602406
118. Bibbins-Domingo K, Chertow GM, Coxson PG, Moran A, Lightwood JM, Pletcher MJ, et al. Projected Effect of Dietary Salt Reductions on Future Cardiovascular Disease. New England Journal of Medicine [Internet]. 2010 Feb 18 [cited 2022 Jul

16];362(7):590–9. Available from: https://www.nejm.org/doi/full/10.1056/nejmoa0907355

119. Konfino J, Mekonnen TA, Coxson PG, Ferrante D, Bibbins-Domingo K. Projected Impact of a Sodium Consumption Reduction Initiative in Argentina: An Analysis from the CVD Policy Model – Argentina. PLoS One [Internet]. 2013 Sep 9 [cited 2022 Jul 16];8(9). Available from: /pmc/articles/PMC3767589/
120. Gillespie DOS, Allen K, Guzman-Castillo M, Bandosz P, Moreira P, McGill R, et al. The Health Equity and Effectiveness of Policy Options to Reduce Dietary Salt Intake in England: Policy Forecast. PLoS One [Internet]. 2015 Jul 1 [cited 2022 May 20];10(7). Available from: https://pubmed.ncbi.nlm.nih.gov/26131981/
121. Nghiem N, Blakely T, Cobiac LJ, Pearson AL, Wilson N. Health and economic impacts of eight different dietary salt reduction interventions. PLoS One [Internet]. 2015 Apr 24 [cited 2022 May 20];10(4). Available from: https://pubmed.ncbi.nlm.nih.gov/25910259/
122. Hyseni L, Elliot-Green A, Lloyd-Williams F, Kypridemos C, O'Flaherty M, McGill R, et al. Systematic review of dietary salt reduction policies: Evidence for an effectiveness hierarchy? PLoS One [Internet]. 2017 May 1 [cited 2022 May 20];12(5). Available from: /pmc/articles/PMC5436672/
123. Kloss L, Meyer JD, Graeve L, Vetter W. Sodium intake and its reduction by food reformulation in the European Union — A review. NFS Journal. 2015 Jun 1;1:9–19.
124. World Health Organization. The SHAKE Technical Package for Salt Reduction. 2016.
125. World Health Organization. WHO global sodium benchmarks for different food categories. Geneva; 2021.
126. Dietary Guidelines Advisory Committee. Scientific Report of the 2015 Dietary Guidelines Advisory Committee: Advisory Report to the Secretary of Health and Human Services and the Secretary of Agriculture. Washington, DC; 2015.
127. Naska A, Berg M-A, Cuadrado C, Freisling H, Gedrich K, Gregorič M, et al. Food balance sheet and household budget survey dietary data and mortality patterns in Europe. British Journal of Nutrition [Internet]. 2008 Jul [cited 2022 Jun 6];102(1):166–71. Available from: https://www.cambridge.org/core/journals/british-journal-of-nutrition/article/food-balance-sheet-and-household-budget-survey-dietary-data-and-mortality-patterns-in-europe/B961F033B49D8B220F9A15C573D5E701
128. Guallar-Castillón P, Muñoz-Pareja M, Aguilera MT, León-Muñoz LM, Rodríguez-Artalejo F. Food sources of sodium, saturated fat and added sugar in the Spanish hypertensive and diabetic population. Atherosclerosis. 2013 Jul;229(1):198–205.
129. Menéndez E, Delgado E, Fernández-Vega F, Prieto MA, Bordiú E, Calle A, et al. Prevalence, Diagnosis, Treatment, and Control of Hypertension in Spain. Results of the Di@bet.es Study. Rev Esp Cardiol (Engl Ed) [Internet]. 2016 Jun [cited 2022 May 17];69(6):572–8. Available from: https://pubmed.ncbi.nlm.nih.gov/26979767/
130. Manuel DG, Lim J, Tanuseputro P, Anderson GM, Alter DA, Laupacis A, et al. Preventive medicine: Revisiting Rose: strategies for reducing coronary heart disease. BMJ : British Medical Journal [Internet]. 2006 Mar 3 [cited 2022 Sep 9];332(7542):659. Available from: /pmc/articles/PMC1403258/
131. Ibsen DB, Laursen ASD, Wuürtz AML, Dahm CC, Rimm EB, Parner ET, et al. Food substitution models for nutritional epidemiology. Am J Clin Nutr [Internet]. 2021 Feb 2 [cited 2022 Jul 9];113(2):294–303. Available from: https://academic.oup.com/ajcn/article/113/2/294/6029242
132. Neira C, Godinho R, Rincón F, Mardones R, Pedroso J. Consequences of the COVID-19 Syndemic for Nutritional Health: A Systematic Review. Nutrients [Internet]. 2021 Apr 1 [cited 2022 Jul 16];13(4):13. Available from: /pmc/articles/PMC8065714/

133. della Valle PG, Mosconi G, Nucci D, Vigezzi G pietro, Gentile L, Gianfredi V, et al. Adherence to the Mediterranean Diet during the COVID-19 national lockdowns: a systematic review of observational studies. Acta Biomed [Internet]. 2021 Oct 1 [cited 2022 Jul 16];92(S6). Available from: https://pubmed.ncbi.nlm.nih.gov/34739464/
134. Zajacova A, Jehn A, Stackhouse M, Denice P, Ramos H. Changes in health behaviours during early COVID-19 and socio-demographic disparities: a cross-sectional analysis. Can J Public Health [Internet]. 2020 Dec 1 [cited 2022 Jul 16];111(6):953–62. Available from: https://pubmed.ncbi.nlm.nih.gov/33170494/

Annex I

Table A 1. Salt reduction policies and studies evaluating salt content in Spain.

Food category	**Salt**		**Year**		
		2009	**2014**	**2016**	**2022**
Bread	**Policy**	-18% (2005-09)*			<1.66[73]
	Content		2.08[115]		
Charcuterie and other Processed meats	**Policy**			-16% (2017-20)[72]	
	Content			2,98	
Ready-to-eat meals	**Policy**			-10% (2017-20)	
	Content			1,36	
Salty snacks	**Policy**			-13,8% (2017-20)	
	Content			1,66	
Vegetable soups	**Policy**			-6,7% (2017-20)	
	Content			0,75	
Sauces	**Policy**			-16 (2017-20)	
	Content			1,65	

Table A 2. Salt reduction policies and studies evaluating salt content in Portugal.

Food category	**Salt**	**Year**							
		2009	**2013**	**2016**	**2018**	**2019**	**2020**	**2021**	**2023**
Bread	**Policy**	≤ 1.4 (l)	≤ 1[75]	-6,7% (2017-20)	≤ 1.3	≤ 1.2	≤ 1.1	≤ 1	<0,3 (canned)
	Content		≤ 0,2[74]	0,75					
Soups	**Policy**								<0,9 (canned)
	Content								
Ready-to-eat meals	**Policy**								
	Content								
Pizzas	**Policy**					-10%(2019-22)			
	Content					1,78			
Breakfast cereals	**Policy**					-10%(2019-22)			
	Content					0,72			
Chips & other snacks	**Policy**					-12%(2019-22)			
	Content								

Table A 3. Salt reduction policies and studies evaluating salt content in Italy.

Food category	**Salt**	**Year**		
		2009	**2013**	**2014**
Bread	**Policy**	-10%(2010-12) (v)		
	Content			
Frozen ready-to-eat meals	**Policy**		-10% (v)	
	Content			

Table A 4. Summary of sources of data considered

SPAIN						
Source of …	**Study**	**Results**	**n**	**Year conducted**	**Ages**	**Methods**
Prevalence of HT	Achievement of Cardiometabolic Goals in Aware Hypertensive Patients in Spain **A Nationwide Population-Based Study**	33.3%	3,983	2008-2010	>18 Y	
Sodium intake	Estimation of salt intake by 24 h urinary sodium excretion in a representative sample of Spanish adults	9,8g/day; SD 4.6	418	2009	18-60 Y	24-hour sodium excretion samples
Main food contributors to salt intake	Sodium Intake from Foods Exceeds Recommended Limits in the Spanish Population: the ANIBES Study (2019)	1.Sausages and other processed meats (+51%) 2.Bread (-5%) 3.Ready-to-eat meals (+23%) 4.Cheese (+10%) 5.Fresh meat (-2%)	2009	2013	9-75 Y	3-day food diaries
Food consumption of main contributors	Current Food Consumption amongst the Spanish ANIBES Study Population					
Food consumption/availability trend	Informe del Consumo de Alimentación en España 2016, 2020		2006:12000 2020:12500	2016, 2020	Households	Household Budget Surveys
Salt content of main contributors across several years	Contenido de sal de los alimentos en España 2012	Cheese 1,04g salt/100g	-	2012	-	Chloride analysis
	Tablas de Composición de Alimentos (Moreiras) 2013	Fresh Meat 0,16g salt/100g	-		-	Laboratory analysis
	Informe del contenido en sal en los alimentos 2019	Sausages and other processed meats 2,98g salt/100g Bread 1,64g/100g Ready-to-eat meals 1,36g/100g	-		-	Food labelling
	PLAN de colaboración para la mejora de la composición de los alimentos y bebidas y otras medidas	Appetizers 1.66g salt/100g Sauces and condiments 1.65g salt/100g Canned soup 0.75g salt/100g	-	2020		Food labelling
PORTUGAL						
Source of …	**Study**	**Results**	**n**	**Year**	**Ages**	**Methods**

				conducted		
Prevalence of HT	INSEF. Prevalence of Hypertension in Portugal: Results from the First National Health Examination Survey	36%	4911	2015	25-74 Y	14,5% sample: 25-34Y 23%: 35-44Y 24%: 45-54Y **38% : 55-75Y** (% nao ponderada)
Sodium intake	IAN-AF (2015-16). Inquérito Alimentar Nacional e de Atividade Física	10,7g/day	6553	2015-16	3m-84 Y	self-reported 2x24h-recalls
	Validation of a new software eAT24 used to assess dietary intake in the adult Portuguese population	8.72g/day	95	2016	18-84Y	24-hour sodium excretion samples
Main food contributors to salt intake **Food consumption of main contributors**	IAN-AF (2015-16). Inquérito Alimentar Nacional e de Atividade Física	1.Bread and "tostas" (-2,86%) 2.Soup -- 3.Charcuterie and other processed meats (+3,02%) 4.Fresh fish, dry or canned (-3,72%) 5.Cheese (+10,83%)	6553	2015-16	3m-84 Y	self-reported 2x24h-recalls
Food consumption/availability trend	Balança Alimentar Portuguesa (2016-20)	Sausages and other processed meats (+51%) Bread (-5%) Ready-to-eat meals (+23%) Cheese (+10%) Fresh meat (-2%)	6553	2016, 17, 18, 19, 20	-	Food Balance Sheets
Salt content of main contributors across several years	IAN-AF (2015-16). Inquérito Alimentar Nacional e de Atividade Física	Bread and "tostas" 1,33g salt/100g Soup 0,31g salt/100g Charcuterie and other processed meats 4,38g salt/100g Fresh fish, dry or canned 1,29g salt/100g Cheese 1,94g salt/100g	-	2015-16	-	FoodEx2
	Redução Do Teor De Sal E Açúcar Nos Alimentos | Relatório Do Progresso Da Reformulação Dos Produtos Alimentares Em Portugal 2018-2021	Ready-to-eat meals 0.9g salt/100g Chips and other salty snacks 1.25g salt/100g Breakfast cereals 0.71g salt/100g Pizzas 1.78 g salt/100g	-	2018-2021	-	Unspecified

	Salt content in pre-packaged foods available in Portuguese market	Canned soups 0.7 g salt/100g	75	2018	-	Food labelling
ITALY						
Source of …	**Study**	**Results**	**n**	**Year conducted**	**Ages**	**Methods**
Prevalence of HT **Sodium intake**	Prevalence and control of hypertension in the general practice in Italy: updated analysis of a large database (2017)	25.9%	911,753	2013	>20Y	12% sample: 20-29Y 35%: 30-49Y 38%: 50-75Y 14%: >75Y
Main food contributors to salt intake	Trend of salt intake measured by 24-h urine collection in the Italian adult population between the 2008 and 2018 CUORE project surveys (2021)	2008-12: M.10.8g, W.8.3g 2018-19: M.9.5g, W. 7.2g	2008-12: 1858 2018-19: 1977	2008-2012 2018-2019	35-74Y	24-hour sodium excretion samples
Food consumption of main contributors	Sodium and Potassium Content of Foods Consumed in an Italian Population and the Impact of Adherence to a Mediterranean Diet on Their Intake (2021)	1. Bread and rolls 2. Processed Meat 3. Pizza, crackers and salty snacks 4. Cheese 5. Other vegetables	719	2005-06 (food consumption)	>18Y	EPIC+FFQ
Food consumption/availability trend	Spese per consumi: Voce di spesa (Ecoicop) (2016-2020)		-	2016-2020	Households	Household Budget Survey
Salt content of main contributors across several years	Sodium and Potassium Content of Foods Consumed in an Italian Population and the Impact of Adherence to a Mediterranean Diet on Their Intake (2021)	Bread and rolls 1,34g salt/100g Processed Meat 2,98g salt/100g Pizza, crackers and salty snacks 1,54g salt/100g Cheese 1,3g salt/100g Other vegetables 0,97g salt/100g	-	2016-17	-	Lab spectrometer

Table A 5. Modelling scenarios for Spain

SPAIN	**Food Groups**	**Mean salt content (g/100g)**	**Food consumption**		**Salt contribution from**
Baseline		**Baseline (2016)**	**Mean**	**SD**	**Mean**
Main contributors to salt intake	Salt added	99.84	1.96		1.96
	Sausages and other processed	2.98[58]	40.50	36.40	1.21
	Bread	2.08[115]	75.00	45.20	1.23
	Ready-to-eat meals	1.36[58]	70.20	77.60	0.95
	Cheese	1.04[59]	18.00	23.00	0.19
	Fresh Meat	0.16[60]	103.90	73.80	0.17
Other foods	Appetizers	1.66[72]	5.50	12.30	0.09
	Sauces and Condiments	1.65[72]	12.90	14.50	0.21
	Canned soup	0.75[72]	15.34		0.12
				TOTAL	**6.12**
	Food Groups	**Mean salt content (g/100g)**	**Food consumption**		**Salt contribution from**
Scenario 1		**Expected (2020)**	**Mean**	**SD**	**Mean**
Main contributors to salt intake	Salt added	99.84	1.96		1.96
	Sausages and other processed	2.50	40.50	36.40	1.01
	Bread	1.66[73]	75.00	45.20	0.98
	Ready-to-eat meals	1.14	70.20	77.60	0.80
	Cheese	1.04	18.00	23.00	0.19
	Fresh Meat	0.16	103.90	73.80	0.17
Other foods	Appetizers	1.43	5.50	12.30	0.08
	Sauces and Condiments	1.39	12.90	14.50	0.18
	Canned soup	0.70	15.34		0.11
				TOTAL	**5.47**

	Food Groups	Mean salt content (g/100g)	Food consumption		Salt contribution from
Scenario 2		**Expected (2020)**	**Mean**	**SD**	**Mean**
Main contributors to salt intake	Salt added	99.84	1.96		1.96
	Sausages and other processed	2.50	40.50	36.40	1.01
	Bread	1.66	75.00	45.20	0.98
	Ready-to-eat meals	1.14	70.20	77.60	0.80
	Cheese	0.87	18.00	23.00	0.19
	Fresh Meat	0.13	103.90	73.80	0.17
Other foods	Appetizers	1.43	5.50	12.30	0.08
	Sauces and Condiments	1.39	12.90	14.50	0.18
	Canned soup	0.70	15.34		0.11
				TOTAL	**5.42**

	Food Groups	Mean salt content (g/100g)	Food consumption		Salt contribution from
Scenario 3		**Expected (2020)**	**Mean**	**SD**	**Mean**
Main contributors to salt intake	Salt added	99.84	1.96		1.96
	Sausages and other processed	2.98	61.16	36.40	1.82
	Bread	2.08	71.25	45.20	1.17
	Ready-to-eat meals	1.36	86.35	77.60	1.17
	Cheese	1.04	19.80	23.00	0.21
	Fresh Meat	0.16	101.82	73.80	0.16
Other foods	Appetizers	1.66	4.57	12.30	0.08
	Sauces and Condiments	1.65	15.35	14.50	0.25

	Canned soup	0.75	15.65		0.12
				TOTAL	6.94
	Food Groups	**Mean salt content (g/100g)**	**Food consumption**		**Salt contribution from**
Scenario 4		**Expected (2020)**	**Mean**	**SD**	**Mean**
Main contributors to salt intake	Salt added	99.84	1.96		1.96
	Sausages and other processed	2.50	61.16	36.40	1.53
	Bread	1.66	71.25	45.20	0.93
	Ready-to-eat meals	1.14	86.35	77.60	0.99
	Cheese	0.87	19.80	23.00	0.17
	Fresh Meat	0.13	101.82	73.80	0.14
Other foods	Appetizers	1.43	4.57	12.30	0.07
	Sauces and Condiments	1.39	15.35	14.50	0.21
	Canned soup	0.70	15.65		0.11
				TOTAL	6.10
	Food Groups	**Mean salt content (g/100g)**	**Food consumption**		**Salt contribution from**
Scenario 5		**Expected (2020)**	**Mean**	**SD**	**Mean**
Main contributors to salt intake	Salt added	99.84	1.60		1.96
	Sausages and other processed	2.50	61.16	36.40	1.53
	Bread	1.66	71.25	45.20	0.93
	Ready-to-eat meals	1.14	86.35	77.60	0.99
	Cheese	0.87	19.80	23.00	0.17
	Fresh Meat	0.13	101.82	73.80	0.14

Other foods	Appetizers	1.43	4.57	12.30	0.07
	Sauces and Condiments	1.39	15.35	14.50	0.21
	Canned soup	0.70	15.65		0.11
				TOTAL	6.10

Categories in blue were assumed stable for that scenario.

Table A 6. Modelling scenarios for Portugal

PORTUGAL	**Food Groups**	**Mean salt content (g/100g)**	**Food consumption**		**Salt contribution from**
Baseline		**Baseline (2020)**	**Mean**	**SD**	**Mean**
Main contributors to salt intake	Added salt	99.84	2.42	1.78	2.42
	Bread and "tostas"	1.33[53]	108.77	84.21	1.45
	Canned soup*	0.7[92]	37.96	43.64	0.27
	Charcuterie and other processed meats	4.38[53]	20.75	30.80	0.91
	Fresh fish, dry or canned	1.29[53]	46.09	59.21	0.60
	Cheeses	1.94[53]	20.85	27.42	0.40
Other foods	Ready-to-eat meals[ə]	-	-	-	-
	Chips and other salty snacks	1.25[93]	2.21	10.13	0.03
	Breakfast Cereals	0.71[93]	7.27	18.35	0.05
	Pizzas	1.78[93]	8.05	37.76	0.14
				TOTAL	**6.04**
	Food Groups	**Mean salt content (g/100g)**	**Food consumption**		**Salt contribution from**
Scenario 1		**Expected (2020)**	**Mean**	**SD**	**Mean**
Main contributors to salt intake	Added salt	99.84	2.42	1.78	2.42
	Bread and "tostas"	1.00	108.77	84.21	1.09
	Canned soup*	0.3	37.96	43.64	0.11
	Charcuterie and other processed meats	4.38	20.75	30.80	0.91
	Fresh fish, dry or canned	1.29	46.09	59.21	0.60
	Cheeses	1.94	20.85	27.42	0.40
Other foods	Chips and other salty snacks	1.13	2.21	10.13	0.02

	Breakfast Cereals	0.60	7.27	18.35	0.04
	Pizzas	1.38	8.05	37.76	0.11
				TOTAL	**5.37**
	Food Groups	**Mean salt content (g/100g)**	**Food consumption**		**Salt contribution from**
Scenario 2		**Expected (2020)**	**Mean**	**SD**	**Mean**
Main contributors to salt intake	Added salt	99.84	2.42	1.78	2.42
	Bread and "tostas"	1.00	108.77	84.21	1.09
	Canned soup*	0.3	37.96	43.64	0.11
	Charcuterie and other processed meats	3.68	20.75	30.80	0.76
	Fresh fish, dry or canned	1.09	46.09	59.21	0.50
	Cheeses	1.63	20.85	27.42	0.34
Other foods	Chips and other salty snacks	1.13	2.21	10.13	0.02
	Breakfast Cereals	0.60	7.27	18.35	0.04
	Pizzas	1.38	8.05	37.76	0.11
				TOTAL	**5.22**
	Food Groups	**Mean salt content (g/100g)**	**Food consumption**		**Salt contribution from**
Scenario 3		**Expected (2020)**	**Mean**	**SD**	**Mean**
Main contributors to salt intake	Added salt	99.84	2.42	1.78	2.42
	Bread and "tostas"	1.33	105.66	81.80	1.41
	Canned soup*	0.7	37.96	43.64	0.27
	Charcuterie and other processed meats	4.38	21.38	31.73	0.94
	Fresh fish, dry or canned	1.29	44.37	57.00	0.57
	Cheeses	1.94	23.10	30.39	0.45

Other foods	Chips and other salty snacks	1.25	2.43	10.83	0.03
	Breakfast Cereals	0.71	6.78	16.27	0.05
	Pizzas	1.78	10.95	41.11	0.19
				TOTAL	6.05
	Food Groups	**Mean salt content (g/100g)**	**Food consumption**		**Salt contribution from**
Scenario 4		**Expected (2020)**	**Mean**	**SD**	**Mean**
Main contributors to salt intake	Added salt	99.84	2.42	1.78	2.42
	Bread and "tostas"	1.00	105.66	81.80	1.06
	Canned soup*	0.3	37.96	43.64	0.11
	Charcuterie and other processed meats	3.68	21.38	31.73	0.79
	Fresh fish, dry or canned	1.09	44.37	57.00	0.48
	Cheeses	1.63	23.10	30.39	0.38
Other foods	Chips and other salty snacks	1.13	2.43	10.83	0.03
	Breakfast Cereals	0.60	6.78	16.27	0.04
	Pizzas	1.38	10.95	41.11	0.15
				TOTAL	5.23
	Food Groups	**Mean salt content (g/100g)**	**Food consumption**		**Salt contribution from**
Scenario 5		**Expected (2020)**	**Mean**	**SD**	**Mean**
Main contributors to salt intake	Added salt	99.84	2.06	1.42	2.06
	Bread and "tostas"	1.00	105.66	81.80	1.06
	Canned soup*	0.3	37.96	43.64	0.11
	Charcuterie and other processed meats	3.68	21.38	31.73	0.79

	Fresh fish, dry or canned	1.09	44.37	57.00	0.48
	Cheeses	1.63	23.10	30.39	0.38
Other foods	Chips and other salty snacks	1.13	2.43	10.83	0.03
	Breakfast Cereals	0.60	6.78	16.27	0.04
	Pizzas	1.38	10.95	41.11	0.15
				TOTAL	4.87

Categories in blue were assumed stable for that scenario.

[3] Data of salt content and food consumption was not available for ready-to-eat meals therefore, because it is not one of the top five contributors to salt intake we decided to not take it into account.

Table A 7. Modelling scenarios for Italy.

ITALY	**Food Groups**	**Mean salt content (g/100g)**	**Food consumption**		**Salt contribution from**
Baseline		**Baseline (2020)**	**Mean**	**SD**	**Mean**
Main contributors to salt intake	Added salt	99.84	1.26		1.26
	Bread and rolls[55]	1.35	78.30	72.00	0.89
	Processed meat [55]	3.00	29.50	24.90	0.74
	Pizza. crackers and salty snacks[55]	1.56	47.50	34.20	0.62
	Cheese[55]	1.31	40.50	33.90	0.44
	Other vegetables[55]	0.98	27.30	20.00	0.22
				TOTAL	**4.74**
	Food Groups	**Mean salt content (g/100g)**	**Food consumption**		**Salt contribution from**
Scenario 2		**Expected (2020)**	**Mean**	**SD**	**Mean**
Main contributors to salt intake	Added salt	99.84	1.26		1.26
	Bread and rolls	1.14	78.30	72.00	0.89
	Processed meat	2.52	29.50	24.90	0.74
	Pizza. crackers and salty snacks	1.31	47.50	34.20	0.62
	Cheese	1.10	40.50	33.90	0.44
	Other vegetables	0.82	27.30	20.00	0.22
				TOTAL	**4.18**
	Food Groups	**Mean salt content (g/100g)**	**Food consumption**		**Salt contribution from**
Scenario 3		**Expected (2020)**	**Mean**	**SD**	**Mean**
Main contributors to salt intake	Added salt	99.84	1.26		1.26
	Bread and rolls	1.35	74.08	68.12	1.00
	Processed meat	3.00	32.89	27.76	0.99
	Pizza. crackers and salty snacks	1.56	45.65	32.87	0.71

	Cheese	1.31	44.93	37.61	0.59
	Other vegetables	0.98	29.06	21.29	0.28
				TOTAL	4.83
	Food Groups	**Mean salt content (g/100g)**	**Food consumption**		**Salt contribution from**
Scenario 4		**Expected (2020)**	**Mean**	**SD**	**Mean**
Main contributors to salt intake	Added salt	99.84	1.26		1.26
	Bread and rolls	1.14	74.08	68.12	0.84
	Processed meat	2.52	32.89	27.76	0.83
	Pizza. crackers and salty snacks	1.31	45.65	32.87	0.60
	Cheese	1.10	44.93	37.61	0.49
	Other vegetables	0.82	29.06	21.29	0.24
				TOTAL	4.26
	Food Groups	**Mean salt content (g/100g)**	**Food consumption**		**Salt contribution from**
Scenario 5		**Expected (2020)**	**Mean**	**SD**	**Mean**
Main contributors to salt intake	Added salt	99.84	0.9		0.9
	Bread and rolls	1.14	74.08	68.12	0.84
	Processed meat	2.52	32.89	27.76	0.83
	Pizza. crackers and salty snacks	1.31	45.65	32.87	0.60
	Cheese	1.10	44.93	37.61	0.49
	Other vegetables	0.82	29.06	21.29	0.24
				TOTAL	3.90

Categories in blue were assumed stable for that scenario.

Table A 8. Projected daily salt intake (g/day)

COUNTRY	Gender and age	Salt intake (g/d)													
		Baseline		Baseline with Corrections		Scenario 1		Scenario 2		Scenario 3		Scenario 4		Scenario 5	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
SPAIN[50]	**M&F 15-19**	9.54	4.61			8.48	4.61	8.40	4.61	10.72	4.61	9.40	4.61	8.87	4.61
	M&F 20-24	9.54	4.61			8.48	4.61	8.40	4.61	10.72	4.61	9.40	4.61	8.87	4.61
	M&F 25-29	9.54	4.61			8.48	4.61	8.40	4.61	10.72	4.61	9.40	4.61	8.87	4.61
	M&F 30-34	10.11	4.61			8.99	4.61	8.90	4.61	11.36	4.61	9.96	4.61	9.40	4.61
	M&F 35-39	10.11	4.61			8.99	4.61	8.90	4.61	11.36	4.61	9.96	4.61	9.40	4.61
	M&F 40-44	10.46	4.79			9.30	4.79	9.21	4.79	11.76	4.79	10.30	4.79	9.72	4.79
	M&F 45-49	10.46	4.79			9.30	4.79	9.21	4.79	11.76	4.79	10.30	4.79	9.72	4.79
	M&F 50-54	9.51	4.46			8.46	4.46	8.37	4.46	10.69	4.46	9.37	4.46	8.84	4.46
	M&F 55-59	9.51	4.46			8.46	4.46	8.37	4.46	10.69	4.46	9.37	4.46	8.84	4.46
	M&F 60-64	9.51	4.46			8.46	4.46	8.37	4.46	10.69	4.46	9.37	4.46	8.84	4.46
	M&F 65-69	9.51	4.46			8.46	4.46	8.37	4.46	10.69	4.46	9.37	4.46	8.84	4.46
	M&F 70-74	9.51	4.46			8.46	4.46	8.37	4.46	10.69	4.46	9.37	4.46	8.84	4.46
	M&F 75-79	9.51	4.46			8.46	4.46	8.37	4.46	10.69	4.46	9.37	4.46	8.84	4.46
	M&F 80-84	9.51	4.46			8.46	4.46	8.37	4.46	10.69	4.46	9.37	4.46	8.84	4.46
	M&F 85+	9.51	4.46			8.46	4.46	8.37	4.46	10.69	4.46	9.37	4.46	8.84	4.46
PORTUGAL[53]	**M15-19**	8.50	2.40	9.79	2.40	8.69	2.40	8.46	2.40	9.80	2.40	8.47	2.40	7.44	2.40
	M20-24	8.90	2.40	10.19	2.40	9.05	2.40	8.80	2.40	10.20	2.40	8.82	2.40	7.74	2.40
	M25-29	9.10	2.50	10.39	2.50	9.23	2.50	8.98	2.50	10.40	2.50	8.99	2.50	7.89	2.50
	M30-34	9.20	2.50	10.49	2.50	9.31	2.50	9.06	2.50	10.50	2.50	9.08	2.50	7.97	2.50
	M35-39	9.30	2.50	10.59	2.50	9.40	2.50	9.15	2.50	10.60	2.50	9.17	2.50	8.05	2.50
	M40-44	9.30	2.50	10.59	2.50	9.40	2.50	9.15	2.50	10.60	2.50	9.17	2.50	8.05	2.50
	M45-49	9.30	2.50	10.59	2.50	9.40	2.50	9.15	2.50	10.60	2.50	9.17	2.50	8.05	2.50
	M50-54	9.10	2.50	10.39	2.50	9.23	2.50	8.98	2.50	10.40	2.50	8.99	2.50	7.89	2.50
	M55-59	9.00	2.50	10.29	2.50	9.14	2.50	8.89	2.50	10.30	2.50	8.91	2.50	7.82	2.50
	M60-64	8.70	2.40	9.99	2.40	8.87	2.40	8.63	2.40	10.00	2.40	8.65	2.40	7.59	2.40
	M65-69	8.40	2.40	9.69	2.40	8.60	2.40	8.37	2.40	9.70	2.40	8.39	2.40	7.36	2.40
	M70-74	8.10	2.40	9.39	2.40	8.34	2.40	8.11	2.40	9.40	2.40	8.13	2.40	7.13	2.40
	M75-79	7.70	2.20	8.99	2.20	7.98	2.20	7.77	2.20	9.00	2.20	7.78	2.20	6.83	2.20
	M80-84	7.20	2.10	8.49	2.10	7.54	2.10	7.33	2.10	8.50	2.10	7.35	2.10	6.45	2.10
	M85+	7.20	2.10	8.49	2.10	7.54	2.10	7.33	2.10	8.50	2.10	7.35	2.10	6.45	2.10
	F15-19	6.80	1.80	8.09	1.80	7.18	1.80	6.99	1.80	8.09	1.80	7.00	1.80	6.15	1.80

	F20-24	6.80	1.80	8.09	1.80	7.18	1.80	6.99	1.80	8.09	1.80	7.00	1.80	6.15	1.80
	F25-29	6.70	1.80	7.99	1.80	7.09	1.80	6.90	1.80	7.99	1.80	6.92	1.80	6.07	1.80
	F30-34	6.60	1.80	7.89	1.80	7.01	1.80	6.82	1.80	7.89	1.80	6.83	1.80	5.99	1.80
	F35-39	6.60	1.80	7.89	1.80	7.01	1.80	6.82	1.80	7.89	1.80	6.83	1.80	5.99	1.80
	F40-44	6.50	1.80	7.79	1.80	6.92	1.80	6.73	1.80	7.79	1.80	6.74	1.80	5.92	1.80
	F45-49	6.40	1.70	7.69	1.70	6.83	1.70	6.64	1.70	7.69	1.70	6.66	1.70	5.84	1.70
	F50-54	6.40	1.70	7.69	1.70	6.83	1.70	6.64	1.70	7.69	1.70	6.66	1.70	5.84	1.70
	F55-59	6.30	1.70	7.59	1.70	6.74	1.70	6.56	1.70	7.59	1.70	6.57	1.70	5.77	1.70
	F60-64	6.20	1.70	7.49	1.70	6.65	1.70	6.47	1.70	7.49	1.70	6.48	1.70	5.69	1.70
	F65-69	6.20	1.70	7.49	1.70	6.65	1.70	6.47	1.70	7.49	1.70	6.48	1.70	5.69	1.70
	F70-74	6.10	1.60	7.39	1.60	6.56	1.60	6.38	1.60	7.39	1.60	6.40	1.60	5.61	1.60
	F75-79	6.00	1.70	7.29	1.70	6.47	1.70	6.30	1.70	7.29	1.70	6.31	1.70	5.54	1.70
	F80-84	6.00	1.60	7.29	1.60	6.47	1.60	6.30	1.60	7.29	1.60	6.31	1.60	5.54	1.60
	F85+	6.00	1.60	7.29	1.60	6.47	1.60	6.30	1.60	7.29	1.60	6.31	1.60	5.54	1.60
ITALY[56]	**M15-19**	9.53	3.88			8.41	3.88	9.71	3.88	8.46	3.88	7.84	3.88		
	M20-24	9.53	3.88			8.41	3.88	9.71	3.88	8.46	3.88	7.84	3.88		
	M25-29	9.53	3.88			8.41	3.88	9.71	3.88	8.46	3.88	7.84	3.88		
	M30-34	9.53	3.88			8.41	3.88	9.71	3.88	8.46	3.88	7.84	3.88		
	M35-39	9.53	3.88			8.41	3.88	9.71	3.88	8.46	3.88	7.84	3.88		
	M40-44	9.53	3.88			8.41	3.88	9.71	3.88	8.46	3.88	7.84	3.88		
	M45-49	9.82	3.71			8.67	3.71	10.01	3.71	8.72	3.71	8.08	3.71		
	M50-54	9.82	3.71			8.67	3.71	10.01	3.71	8.72	3.71	8.08	3.71		
	M55-59	9.59	3.53			8.46	3.53	9.77	3.53	8.51	3.53	7.89	3.53		
	M60-64	9.59	3.53			8.46	3.53	9.77	3.53	8.51	3.53	7.89	3.53		
	M65-69	9.53	3.47			8.41	3.47	9.71	3.47	8.46	3.47	7.84	3.47		
	M70-74	9.53	3.47			8.41	3.47	9.71	3.47	8.46	3.47	7.84	3.47		
	M75-79	9.53	3.47			8.41	3.47	9.71	3.47	8.46	3.47	7.84	3.47		
	M80-84	9.53	3.47			8.41	3.47	9.71	3.47	8.46	3.47	7.84	3.47		
	M85+	9.53	3.47			8.41	3.47	9.71	3.47	8.46	3.47	7.84	3.47		
	F15-19	7.12	2.76			6.28	2.76	7.26	2.76	6.32	2.76	5.86	2.76		
	F20-24	7.12	2.76			6.28	2.76	7.26	2.76	6.32	2.76	5.86	2.76		
	F25-29	7.12	2.76			6.28	2.76	7.26	2.76	6.32	2.76	5.86	2.76		
	F30-34	7.12	2.76			6.28	2.76	7.26	2.76	6.32	2.76	5.86	2.76		
	F35-39	7.12	2.76			6.28	2.76	7.26	2.76	6.32	2.76	5.86	2.76		
	F40-44	7.12	2.76			6.28	2.76	7.26	2.76	6.32	2.76	5.86	2.76		
	F45-49	7.24	2.76			6.39	2.76	7.38	2.76	6.43	2.76	5.96	2.76		
	F50-54	7.24	2.76			6.39	2.76	7.38	2.76	6.43	2.76	5.96	2.76		

	F55-59	7.65	3.24			6.75	3.24	7.80	3.24	6.79	3.24	6.29	3.24		
	F60-64	7.65	3.24			6.75	3.24	7.80	3.24	6.79	3.24	6.29	3.24		
	F65-69	7.12	2.71			6.28	2.71	7.26	2.71	6.32	2.71	5.86	2.71		
	F70-74	7.12	2.71			6.28	2.71	7.26	2.71	6.32	2.71	5.86	2.71		
	F75-79	7.12	2.71			6.28	2.71	7.26	2.71	6.32	2.71	5.86	2.71		
	F80-84	7.12	2.71			6.28	2.71	7.26	2.71	6.32	2.71	5.86	2.71		
	F85+	7.12	2.71			6.28	2.71	7.26	2.71	6.32	2.71	5.86	2.71		

Values in red were assumed as the previous/posterior category

Annex II. Article to submit to the British Journal of Nutrition

Modelling the Impact of Salt Reduction Policies on Cardiovascular Mortality and Hypertension in Southern European Countries

N. Lorenzo i Sunyer[1,2*], M. Severo[1,3], M. J. Gregório[1,4], C. Lopes[1,2]

1 **EPIUnit/ITR – Public Health Institute, University of Porto**
2 **Public Health and Forensic Sciences, and Medical Education Department, Faculty of Medicine, University of Porto**
3 **Institute of Biomedical Sciences Abel Salazar, University of Porto**
4 **Faculty of Nutrition and Food Sciences, University of Porto**

*Corresponding author
Nora Lorenzo i Sunyer
EPIUnit – Public Health Institute, University of Porto, Rua das Taipas, nº 135, 4050-600 Porto, Portugal
Tel: +351 222061820
Fax: +351 222061821
e-mail: nora.lorenzo.sunyer@gmail.com

Short title (max. 45 characters with spaces): **Salt Policies in Southern European countries**

Keywords: salt reduction policies, cardiovascular diseases, nutritional epidemiology, health policies.

Abstract

The impact of salt reduction policies on cardiovascular outcomes in Southern Europe has been underexplored. This study assessed the effect of salt reformulation policies on hypertension and cardiovascular mortality in Spain, Portugal and Italy. For each country, foods most contributing to salt intake, its salt content, consumption and availability/sales trends in the period 2016-2020 were identified. Changes in salt intake were examined through five scenarios assuming other risk factors as stable: (1) salt content reduction based on current policies; (2) scenario 1 plus future policies targeting top five food contributors; (3) salt change by food consumption trend; (4) combination of scenario 2 plus scenario 3; (5) scenario 4 plus a reduction in added salt. Impact on hypertension was quantified using relative risk shift and assuming a continuous linear regression between salt intake and blood pressure. Changes in cardiovascular deaths were estimated using WHO-PRIME. Incidence of hypertension and cardiovascular deaths were expected to increase if no policies were implemented (scenario 3) in Spain (+14.68% and +5.18%), Portugal (+0.65% and +0.04%) and Italy (+0.10% and +0.72%). However, if policies had targeted top five contributors to salt intake (scenario 4), 439 cardiovascular deaths per year could have been avoided in Spain, 871 in Portugal and 4,250 in Italy. This study suggests that current salt reduction policies in Spain and Portugal could be effective at reducing salt intake. However, for better outcomes, future policies need to tackle those foods identified as the highest contributors to salt intake to mitigate its increasing trend of consumption/availability.

Introduction

In Southern European countries, cardiovascular (CV) mortality rates have declined over the last decades but they still remain as the leading cause of death(1–4). In 2019, stroke and ischaemic heart disease (IHD) accounted for 8.65% and 12.51% of all deaths in Spain, 14.34% and 11.16% in Portugal and, 10.48% and 15.75% in Italy, respectively(4). Aligned with this burden, high systolic blood pressure (SBP) is the main risk factor contributing to more deaths and among the top four risk factors contributing to more disability-adjusted life years (DALYs) in Spain, Portugal and Italy. Similarly, dietary risk factors, particularly "diet high in sodium" have still a strong weight on the disease burden among Southern European countries although reductions have occurred between 1990 and 2019(4).

In Spain, prevalence of hypertension is estimated to be 33.3% based on the results from a 2008-2010 study that evaluated a sample of 11,957 individuals aged >18 years and representative of the Spanish population(5). In Portugal, the National Health Examination Survey (INSEF)(6) assessed the health of a representative population of 4,911 adults with ages 25–74, finding that prevalence was 36%. In Italy, in 2013 data from 911,753 patients of a large representative sample of general practitioners was analysed retrospectively and results indicated that hypertension was prevalent in 25.9% individuals of the sample with ages ranging from 20 to >90 years old(7).

Although salt is essential for humans, the impact of excessive salt intake has been studied extensively with most research focused on the effect on gastric cancer(8) and cardiovascular diseases (CVDs). Higher sodium consumption is associated with higher blood pressure and hypertension(9–12), with a 1.12-fold increased risk of CVD and 1.23 of stroke(13). However, the impact that salt intake has on the increased risk of CVD is thought to be mediated by the higher blood pressure and not described as a direct relationship(12).

Strong evidence supports that reductions in sodium intake lead to decreases in SBP and overall blood pressure(11,13,14) with stronger effects among hypertensive subjects(15–17). Furthermore, potassium intake can change sodium/potassium ratio and modify the impact sodium has on blood pressure(9,18).

For most European countries 70–75% of all sodium intake comes from processed foods (i.e. bread), 10–15% is naturally present in unprocessed foods and, discretionary sodium (table salt and added during cooking) accounts for 10–15%(19,20).

To assess salt intake in the diet, the reference methodology is using sodium biomarkers in 24-h urinary sodium excretion samples(21,22) over dietary self-reporting methods (i.e. 24-h recalls). In Spain, salt intake has been estimated to be of 9.8g/day, 11.5g/day for men and 8.4g/day in women, based on 24-h urinary sodium excretion of adults aged >18years old (23) while a study on a population with ages 9-75 years old using 3-day food diaries reported that it was around 5.06g/day, excluding discretionary salt(24). In Portugal, a study conducted in 2011-12 collecting 24-h urinary sodium samples from adults (25-74 years old) quantified sodium intake to be of 10.7g/day(25). However, the National Food, Nutrition and Physical Activity Survey (IAN-AF 2015-16)(26) using self-reported, in a sample from 3 months to 84 years, reported an average of

7.4g/day (8.6g/day in men vs. 6.4g/day in women) and highest (7.8g/day) for adults with ages 18 to 64 years old. Afterwards, research evaluating a sub-sample of 95 adults estimated that sodium excretion in adults was 10.01g of salt using 24-h urinary excretion and based on self-reported methods, the intake of salt was 8.72g per day(27). In Italy, a regional survey using validated semi-quantitative food frequency questionnaire estimated that salt consumption among adults aged over 18 years old was 5.38g/day(28). Later, using 24-h urinary excretion samples of adults, salt intake was estimated to be 10.8g/day for men and 8.3g/day for women in 2008–2012 and, 9.5g/day and 7.2g/day for men and women, respectively, in 2018–2019(29).

Main food contributors to sodium intake were identified in the different countries using different sources. In Spain, foods were identified using 3-day diaries being **(1)** processed meats; **(2)** bread; **(3)** ready-to-eat meals; **(4)** cheese and **(5)** fresh meat(24). In Portugal, based on the two non-consecutive 24-h recalls employed in the IAN-AF 2015-16, food categories included **(1)** bread; **(2)** vegetable soup; **(3)** processed meats; **(4)** fish (fresh, dry or canned and **(5)** cheese(26). In Italy, they used a validated semi-quantitative food frequency questionnaire and a study evaluating the salt content of food products, reporting that the main contributors were **(1)** bread; **(2)** processed meats; **(3)** pizza and salty snacks; **(4)** cheese and **(5)** other vegetables (i.e. canned or preserved)(28).

According to the WHO's *Best Buys* to reduce unhealthy diets, policies focusing on reducing salt intake, prevent and control non-communicable diseases (NCDs)(30,31). Sodium reduction policies in Spain, Portugal and Italy, have focused on establishing national initiatives, increasing consumer awareness, labelling and industry involvement(22,32). In Spain and Portugal a law has been enforced to reduce salt content in bread (<1.66g /100g bread from April 2022 in Spain (33) and ≤1 g/100g bread from 2021 in Portugal (34)) and an agreement was established between the Government and the food industry to reformulate certain foods. In Spain these included lowering salt content in charcuterie and other processed meats, sauces, ready-to-eat meals, salty snacks, and vegetable soups(35). And, in Portugal salt limits agreements were applied to canned soups, ready-to-eat meals, pizzas, breakfast cereals and other snacks(36). In Italy, agreements have been approved at regional level or with certain sectors (i.e.2009-10 an agreement with Baker Associations aimed to reduce salt content by 10–15% in bread within 2 years) however, there has been no published data on the effective reformulation of these foods(22,37–39).

Only one study has estimated the impact of overall salt intake reductions on CV morbidity (prevalence of ischaemic heart disease and stroke) and mortality in Spain and Italy but it did not identify the impact on hypertension, the main risk factor for CV outcomes(40). In the case of Portugal, only one study assessed the impact of current policies but it only evaluated the potential effect of salt reformulation in bread on blood pressure(41).

There is a gap in the literature of studies that evaluate specific food reformulation policies (i.e. targeting one specific food category) and their impact on CV outcomes. Furthermore, no studies have evaluated the food availability/sales trend of the main foods contributing to salt intake. Therefore, the main aim of this study is to evaluate the impact specific salt reformulation policies on CV morbidity (hypertension) and mortality in Spain, Portugal and Italy. We included national policies that have been already implemented and future interventions we are proposing to target the largest contributors to salt intake.

Methodology

1. Data Sources

The current study required to collect data from many different sources. A summary of all the sources used can be found in Supplementary Table S1.

1.1. Populational Salt Intake

Data using 24-h urinary collection samples of >200 individuals was available for Spain and Italy. Although we prioritized the studies using these methodologies for baseline estimates of daily salt intake, some other factors were considered and we used another strategy for Portugal. Find below the studies chosen for each country.

For Spain, we considered the study conducted by Ortega et al.(23) on 418 individuals aged 18 to 60 years considered to be a "representative sample of the Spanish young and middle-aged adult population" and found salt intake to be 9.8g/day. Fifteen different provinces (considering as many Spain's autonomous regions as possible) were chosen through random sampling and residents from the region were then randomly selected and contacted through telephone. Included participants were apparently healthy and lived at home (not hospitalized) thus, they were excluded if they had been diagnosed with pathologies such as diabetes or hypertension.

For Portugal, as previously mentioned, the PHYSA study measured sodium excretion from a sample of 3,720 Portuguese, however, we lacked access to the data specific for age and gender which was necessary for the CV mortality model (42). Therefore, we decided to include the self-reporting estimates of 7.4g/day from the IAN-AF 2015-16(26). Although, as previously mentioned, self-reporting methods often lead to under-reporting and 24-h urinary excretion is preferred over dietary intake data(43), we considered a sensitivity analysis correction. The Portuguese National Dietary Survey collected 24-h urinary samples of 95 adults aged 18 to 84 years old from all the IAN-AF 2015-16 sample. Based on the data from these 95 adults they were able to quantify salt intake (10.1g/day) and the accuracy between the two non-consecutive 24-h dietary recall and the 24-h urinary sample(27). We used these values to conduct a sensitivity analysis and correct individual self-reported salt intake data (Table S2).

The 2018-2019 CUORE project survey(29) which has been considered as the reference point for Italian data, estimated salt intake was 9.5g/day for men and 7.2g/day for women,. They randomly selected age and sex-specific 24-h urinary sodium excretion samples of 100 men and 100 women with ages between 35 and 74 in 10 different Italian regions.

1.2. Salt Content and Food Consumption of Foods

The different counterfactual scenarios of this study considered reformulation for salt content in different food products depending on the country. Current policies in Spain already effectively tackled 60% of the main five food contributors for salt however, only 40% were targeted in Portugal and 0% in Italy (Table 2).

Main food contributors to salt in the diet are calculated using data on the foods consumed and the salt content of that foods. Thus, for each country sources of information for contributors to salt intake included food consumption and salt content which can come from the same or different sources.

For Spain, we considered results from several studies. Within the ANIBES research (44), we considered two reports, one for the main contributors to salt intake and a second one for evaluating the daily intake of these foods. ANIBES is a cross-sectional study where data was collected from a representative sample of 2,009 individuals with ages between 9-75 years old from 128 sampling points in Spain in 2013. Participants were asked to compile a 3-day food diary (two working days and one weekend day) to evaluate their diet.
Food consumption estimates of canned soup were not available from the ANIBES reports thus, we chose the Mercasa report(45) which provided a yearly average intake for soups. In Spain, the category of soups included broths, soups and cream (soup of thicker consistency).
Salt content from national reports that evaluate sodium content through food labelling and laboratory quantification were prioritized over food composition tables because they are more precise and have a better representation of the foods more consumed by the population. These national reports include those with higher sales and as many food categories and food companies involved in the agreement as possible. We considered the 2016 report for the salt content of processed meats and ready-to-eat meals (46). However, for bread we considered a study that evaluated salt content in 1,137 loaves of bread in 2014(47) and for cheese we used data from a 2012 report that quantified sodium using chloride determination (48).
No data was available for fresh meat in the national reports thus, we decided to use data from a food composition table(49). We assumed that the average sodium content in fresh meat corresponded to the average of sodium in all meats classified as fresh with equal representation.
Lastly, for salty snacks, sauces and canned soup we used results reported in the more recent study published in 2020 that included salt content in 2016(35).

In Portugal, the IAN-AF 2015-16(50) identified the main contributors and provided values of their daily consumption and salt content. The national dietary survey was conducted between 2015 and 2016 and assessed the nutritional habits of 6,553 individuals with ages between 3 months and 84 years old. Participants were selected randomly through multistage sampling from the Portuguese National Health Registry including a total of 99 health centres across the national territory. Data was collected through an electronic platform "You eAT&Move" that included three different modules, one of which is the module "eAT24"(27). eAT24 allowed to compile data on food consumption through two non-consecutive self-reported 24-h recalls on adults aged over 10. The platform was connected to food composition tables to use the estimates for nutrient intake such as salt content(51). Thus, data on salt content and food consumption of the main contributors to salt intake was considered from the IAN-AF 2015-16. Furthermore, we used individual data from the dietary survey for the calculations. However, the IAN-AF reports only salt content for the general category of "soup" thus, we considered a Portuguese study that quantified salt content in packaged soup available in the Portuguese supermarkets(52). Salt content for other products such as breakfast cereals, pizzas, chips and salty snacks was considered from a report of the DGS published in 2022 (53).

In Italy, Malavolti et al.(28) led a study that assessed the sodium content of the most common foods in the Italian diet. This research included two different interventions, one focused on evaluating the food consumption among the Italian population, and the second one evaluated the salt content of the foods identified. The first study was carried out in 2005-2006 in the Center-North Italian region of Emilia-Romagna where they evaluated the dietary intake of 719 participants over the age of 18 years. The sample population was identified through random sampling from the Italian National Health Service Registry. They utilized FFQ used within the "European Prospective Investigation into Cancer and Nutrition" known as EPIC-FFQ adapted to the Italian Northern population. Although, as previously mentioned two 24-h recalls are the most preferred methods to evaluate food intake, the EPIC-FFQ is a validated semi-quantitative questionnaire that "assesses frequency and quantity of consumption over an entire year, and takes into account intakes of seasonal food, supporting its substantial validity and reproducibility for the assessment of dietary habits in the adult population"(28).
A second examination was conducted between 2016 and 2017 to evaluate food samples from food markets and grocery stores in Emilia-Romagna based on foods consumed more frequently in that region. Sodium concentrations from the samples were measured using a spectrometer. Results of salt content were considered as baseline values for our study(28).

1.3. "Food Consumption Trend"

In the current study, "food consumption trend" was considered as the changes in availability or sales for several food categories over a period of 4 years.
The methodology of the studies considered to estimate the "food consumption trend" at the national level differed between countries. To conduct the calculations for our study we only used these estimates to model a "food consumption trend". Thus, although the methods for each country reported the results in different units, that was not an obstacle to our analysis.

In Spain, the Household Budget Survey (HBS) published yearly by the Ministry of Agriculture, Fishery and Food gives values on the domestic availability of several food products based on their expenditure. A sample of households (12,000 in 2016 and 12,500 in 2020) was chosen randomly across all the national territory and asked to record their purchases with a scanner. The results report the average annual food consumption (kg/person per year)(54,55).

For the case of Portugal, we considered data from the National Food Balance Sheets (FBS), *Balança Alimentar Portuguesa*, published by the Instituto Nacional de Estatística (INE) on food availability of the main contributors to sodium intake in 2016 and 2020. Although there were HBS available, *Inquéritos Orçamentos Familiares*, the last report was published in 2015-16 which was not ideal for the periods considered in our study. The FBS are published every 5-years (the latest reports were in 2016 and 2020) with yearly estimates of food availability. Based on the annual values, they report results on all food products in g/person per day. The only specific food category to the main contributors to salt intake was cheese, for the other categories we assumed the overall classification. Changes in cereals were attributed to the category of bread and "tostas"; variation in meat to charcuterie and other processed meats; lastly, fresh fish, dry or canned was considered to follow the same trend as overall fish(56). For soup and "ready-to-eat meals" we considered that availability was stable because we lacked data. However, for policies tackling breakfast cereals, pizzas, chips, and salty snacks we used sales reported by Nielsen IQ per year from 2018 to 2021(53).

In Italy, the National Institute of Statistics (*Istituto Nazionale di Statistica* – ISTAT) is the responsible body to conduct the HBS in Italy, Spese per consumi: Voce di spesa. Their more recent reports follow the European Classification of Individual COnsumption by Purpose (ECoicop) using an online personal interview. They collect data on the expenditure on goods such as the purchase of foods. Results indicate the average monthly expenditure by household in €. As in Portugal for all the food categories, except for bread, we assumed the food consumption of the most similar or broader category (i.e. for processed meat we considered the values of charcuterie, for cheese we considered values from cheese and dairy products)(57).

1.4. Prevalence of Hypertension

According to guidelines from the European Society of Cardiology, high blood pressure also known as hypertension is defined as systolic blood pressure ≥140 mmHg and/or diastolic blood pressure levels ≥90 mmHg. However, hypertension is often referred to as high Systolic Blood Pressure (SBP)(58).

Incidence studies were our first choice because it allows to calculate better the prevented new cases of hypertension in our CV morbidity model. However, incidence was only available for Portugal. In order to calculate an approximative incidence for Spain and Italy, we used the prevalence and incidence of Portugal and the correspondent prevalence in that country (Spain or Italy). This will be further explained in the statistical analysis section.

For Spain, we considered a paper that had studied in 2008-2010 a representative sample of 11,957 Spanish individuals aged over 18 years old. This nationwide population-based study recruited their participants through multistage clustered (municipalities and census) random sampling. Within each cluster, random telephone dialing was used and individuals were chosen according to the gender and age distribution of the Spanish population. A total of 3,983 indviduals had hypertension which indicates a prevalence of 33.3% within this noninstitutionalised population(5).

In Portugal, we used the incidence values from a population-based cohort (EPIPorto) on 796 adults >18years old conducted in 1999-2003. Incidence rate among these non-hypertensive population was found to be 47.3 per 1000 persons-years(59). Prevalence was taken from the National Health Examination Survey(60), a cross-sectional study that assessed the health of 4,911 individuals aged between 25 and 74 years and reported that the prevalence of hypertension among the Portuguese population was estimated to be 36%. Participants were selected by random sampling from the Portuguese National Health Service database. The survey included a health examination (including blood pressure measurements), a blood sample collection and an interview.

Lastly, in Italy, the prevalence of hypertension was assessed through analysis of patient records from a representative sample of general practitioners distributed across all the Italian regions. General practitioners that agreed to participate in the study, input data measurements of their patients. A total of 911,753 patient records older than 20 years were evaluated and hypertension was estimated to be prevalent in 26% of the population. Although, undiagnosed hypertension could have been high in this case because only those patients that had been previously diagnosed as hypertensive were included in the estimates(7).

1.5. Population and Mortality data

The National Statistics Institution of each country (INE for Spain, INE for Portugal, and ISTAT for Italy) publish reports including the demographics of their population and mortality causes. We collected data from national census(61–63) and causes of death classified according to the International Statistical Classification of Diseases and Related Health Problems, 10th revision (ICD-10). For the cardiovascular mortality model, we needed mortality data that was aggregated in the ICD-10 way considering the following categories I60-I69 cerebovascular diseases; I20-I25 Ischaemic heart diseases; I10-I15 hypertensive disease; I50 heart failure; I71 aortic aneurysm; I26 pulmonary embolism and I05-I09 rheumatic heart disease. However, Italian data was categorized using another coding and for some causes of death, data was aggregated in a different way. We could not assume deaths specific for these specific diseases (C23 – Gallbladder, I10-I15 – Hypertensive disease, I71 – Aortic aneurysm, I26 – Pulmonary embolism, I05-I09 – Rheumatic heart disease). Therefore, we estimated the deaths using data from Spain and made it proportional to the size of the Italian population(64–66).

2. Counterfactual Scenarios

In this study, we assessed the impact of five different counterfactual scenarios on both cardiovascular mortality and morbidity (Table 1).

1) The first counterfactual scenario took only into account a reduction of the salt content based on the current national policies for food reformulation even if they did not target the main contributors to salt intake. Food consumption of the food categories targeted was assumed stable. This scenario was considered for Portugal and Spain but not for Italy (more details on the reason on the next point). Additionally for Portugal, for the current policies targeting breakfast cereals, pizzas, chips and salty snacks, we considered either the expected goal or the current content (if a category had overachieved the goals).
2) The second counterfactual scenario considered not only the current policies but also proposed additional goals based on the EC recommendations(67) for the top five salt contributors that had not been tackled by the policies. Food consumption of the food categories targeted was assumed stable.
3) The third counterfactual scenario took into consideration that only consumption of the foods targeted by policies (either current or future proposed by the current study) changed based on the "food consumption trend" estimates (changes in availability or sales of food products) while maintaining salt content in all food products constant.
4) The fourth counterfactual scenario considered the combination of the second and third scenarios in which both food reformulation and dietary intake differed according to current and future policies.
5) The last counterfactual scenario corresponded to scenario four but with an additional public health campaign to reduce "1 pinch of salt less a day". This would lead to a reduction of the added salt and to reduce discretionary salt overall.

Regarding scenario 5, reductions in added salt were calculated based on decreases in discretionary salt. In Portugal, the IAN-AF 2015-16 study (26) estimated that discretionary salt intake was 29% of total salt intake. For Spain, results reported that approximately 72% of sodium comes from processed foods, 20% from added salt and 8% is present naturally in the foods(68). However, this was not the case for Italy where data on discretionary salt intake is lacking. Based on the Portuguese and Spanish values, a baseline was estimated for Italy assuming that discretionary salt accounted for 20%, similarly to Spain. We recognize this might be an underestimation since for Portugal it was 29%, however, we preferred to have a more conservative approach.

2.1. Policies Considered

The food policies considered in the first and second scenario were different. The first counterfactual scenario considered food reformulation agreements/policies that had been already implemented even if they targeted food categories that were not among the top contributors to salt intake. For the second scenario, we proposed additional targets based on the recommendations from the High-Level Group on Nutrition and Physical Activity (Committee from the European Commission)(67) to reduce by -16% the salt content of the main

national contributors. This methodology was also used for some subgroups in the case of Portugal (charcuterie; fresh fish, dry or canned; and cheese) and Spain (cheese and fresh meat). Although agreements had been established with the industry in Italy, no monitoring data of the reformulation effectiveness has been published and the salt content study values from 2016 we considered were after the theoretical reformulation timeline (2010-2012). Therefore, because we did not know if the salt content in bread of 2016 is the result of the reformulation or if it had not happened yet, we assumed that the reformulation had not occurred and we did not consider the first scenario for Italy. In the second scenario for Italy, we proposed to target all food products considered as main contributors.
To get a better overview of the foods targeted by current policies and the ones we are proposing see Table 2.

3. Statistical Analysis

The methodological structure for this current study can be seen in Figure 1. The statistical analysis consisted of two parts. The first part, corresponding to the estimation of the food consumption and salt intake trends was common for the CV morbidity model and the CV mortality Preventable Risk Integrated ModEL (PRIME). However, the second part, on estimating the health impact, was different for each model mainly because the PRIME had already been developed to estimate the impact on CV mortality, however, for CV morbidity we had to develop a new model.

3.1. The “Food Consumption” trend (2016-2020)

In this first step used for both the CV morbidity and CV mortality model, we collected food availability/sales statistics from different points in time to ultimately model a “food consumption trend” for all food products considered in scenarios 1 and 2. Then, this trend was used to simulate these changes in the food consumption of each product.

In the case of Spain and Italy, to estimate the trend of the food products (θ), we used the data from food availability and sales in 2016 and 2020. In Portugal, for pizzas, breakfast cereals and chips and other snacks, we also calculated the trend based on sales data from 2018 and 2021. We adjusted the estimates for these three years for the four years of 2016-2020. However, the other food categories in Portuguese FBS already calculated the trend for the other food categories.

(formula 1)

$$\boxed{\theta = \frac{(FCA_{2020} - FCA_{2016})}{FCA_{2016}}}$$

3.2. Projected changes in Salt Intake

We aimed to establish a baseline of salt intake based on food consumption and salt content data. We did not expect this calculation to match the national estimate of salt intake, because it only took into account those foods contributing the most to salt intake or were targeted by foods. However, this rough estimation allowed us to see how salt intake changes in each scenario (i.e. the increase/decrease of salt in each scenario respective to the baseline).

Policies between countries were implemented in different years and food consumption and salt content studies also differed a lot. Fortunately, the "food consumption trend" from 2016 until 2020 was available for all countries and nearly all food products. Thus, to harmonize the period of our study we defined 2016 as the baseline and 2020 as the final year. Meaning that if a study was conducted in 2013, we assumed the results in 2013 as the baseline for 2016. Similarly, we assumed that all policies would have been implemented by 2020, even if they were expected to be enforced after our study period.

To estimate the projected individual salt daily intake if the targets were achieved fully ($\boldsymbol{y_{id}}$), we used the following formula where $\boldsymbol{x_{idf}}$ corresponds to the individual (i) daily consumption (d) of a certain food item (f) and $\boldsymbol{c_f}$ refers to the salt content of the food item assuming salt targets are met.

(formula 2)

$$\boxed{\boldsymbol{y_{id} = \sum_{f} x_{idf} \cdot c_f}}$$

At baseline, daily consumption ($\boldsymbol{x_{idf}}$) and salt content ($\boldsymbol{c_f}$) values corresponded to data extracted from our source studies and assumed that it was representative for 2016. Then, $\boldsymbol{y_{id}}$ was considered as the projected daily salt intake in 2020.

For each counterfactual scenario, we made the correspondent changes to the daily consumption ($\boldsymbol{x_{idf}}$) and salt content ($\boldsymbol{c_f}$) of each food, based on the assumptions described in Table 1 and estimated the daily salt intake ($\boldsymbol{y_{id}}$) in 2020. For scenarios 1 and 2 considering salt reduction policies, we changed salt content ($\boldsymbol{c_f}$) of each food according to the reduction expected if the target was achieved by 2020. For scenario 3, daily consumption ($\boldsymbol{x_{idf}}$) was modified according to the "food consumption trend" calculated (i.e. if the "food consumption trend" of bread was expected to increase by +51%, we multiplied food consumption of bread by 1.51). Scenario 4 included a combination of adjustments (reduction salt content and decrease/increased daily consumption) in salt content ($\boldsymbol{c_f}$) and daily consumption ($\boldsymbol{x_{idf}}$). Lastly, in scenario 5, we considered the same changes as counterfactual scenario 4 but with additional modifications in the daily consumption ($\boldsymbol{x_{idf}}$) of discretionary salt. More specifically, for this last scenario, we assumed a reduction of "1 pinch of salt less a day" (1 pinch of salt = 0,36 of salt) of the discretionary salt for each country.

After the necessary changes, we obtained the expected daily salt intake ($\boldsymbol{y_{id}}$) in 2020 for each scenario. We then proceeded to calculate the change in daily salt intake (∂) between the baseline ($\boldsymbol{y_{id\ baseline}}$) and each counterfactual scenario ($\boldsymbol{y_{id\ scenario}}$).

(formula 3)

$$\boxed{\partial = \frac{(y_{id\,scenario} - y_{id\,baseline})}{y_{id\,baseline}}}$$

3.3. Modelling Data Analysis on Cardiovascular Mortality

To estimate the effect of population-level interventions related with salt intake on Cardiovascular mortality, we used the PRIME November 2017 version) an openly available NCD scenario model(69). The PRIME tool allows to evaluate the impact at the population level when changing specific NCD risk factors on the annual deaths from NCDs(70). This tool has been developed by researchers at WHO Collaborating Centre on Population Approaches for NCD Prevention, Nuffield Department of Population Health, University of Oxford, to provide the WHO Europe Member States with some guidance on achieving the SDG 3.4 (by 2030 reduce by one-third pre-mature mortality from NCDs through prevention and treatment and promote mental health and wellbeing). The values that the model uses to estimate the changes in mortality proceeds from peer-reviewed meta-analyses. Users must input three sets of data (age and sex distribution of the population; NCD mortality rates for a given year; risk factors) to then simulate different scenarios modifying one or more risk factors and obtain the predicted changes in the mortality of 24 NCDs.

In the current study, for each country, we provided data on the i) average daily intake of salt (g/d) for the population and standard deviation, ii) age and sex distribution of the population, and, iii) mortality rates for each disease per year. This salt intake was calculated using Eq. 1, 2 and 3, previously discussed. The only risk factor we modified between scenarios was salt intake thus, for the other modifiable factors (i.e. physical activity, alcohol consumption) we assumed them stable. The result of our analysis was the number of deaths (due to several CVDs) averted per year if the targets defined for each counterfactual scenario were achieved (Table 2). The PRIME model can only compare a historical scenario with a counterfactual scenario and provide the predicted mortality for that same year thus, it cannot be used to predict future trends.

The Monte Carlo analysis was used to provide a realistic 95% CI around the number of deaths averted by using relative risk values to estimate the expected changes in mortality. We ran the model 5000 times to consider the uncertainty of the deterministic result (69).

For the salt intake estimates of Portugal, we decided to use the self-reported data form the national survey IAN-AF 2015-16(27) self-reported results, however, as previously mentioned, they can often be biased by errors. Thus, we performed a continuity correction using data from the IAN-AF 2015-16 subsample of 95 adults that was used to validate the new software used for the national dietary survey.

(formula 4) $$\boxed{y_{id\_corrected} = y_{id\_sodium\_excretion} - y_{id_{sodium\_selfreported}}}$$

Based on the results from Goios et al.(27), estimated sodium intake from sodium excretion was 4,003mg while self-reporting data reported 3,489mg. Therefore, using formula 4, there was a misreporting of 514mg of sodium per day (1.285g of salt per day). Consequently, we added 1.285g/day to all salt intake baseline values for Portugal (see Table A10 in the Annex).

3.4. Modelling Data Analysis on Cardiovascular Morbidity (Hypertension)

To estimate the impact on new hypertension cases we established a model that quantified the potential impact fraction (PIF) and prevented cases based on changes in salt content and food consumption.

The analysis was performed according to the presence of individual data (Portugal) or aggregated data (Spain and Italy).

In the case of Portugal, individual dietary intake data was calculated according to the trend of each scenario. In the case of aggregated data (Italy and Spain) we simulated individual daily consumption of each food group (x_{idf}) considering the sample size of the IAN-AF 2015-16; the mean and standard deviation according to the consumption in each country, obtained from literature and Multivariate Normal Distribution with the same covariance matrix as the Portuguese sample. Nevertheless, when the food group did not exist in the Portuguese data, we assumed the covariance was zero.

Then, formula 2 was applied in order to obtain individual salt daily intake for each scenario (y_{id}). A bootstrapping was performed with 100 replicas to obtain a PIF bootstrap confidence interval by quantiles.

Estimating relative risk using a linear regression

Previous studies assessing the impact of salt policies(41,70) considered McGregor et al.(71) as the reference values for the association between SBP and sodium excretion. The report included 34 trials of at least 4 weeks of duration since it had been described that short-term experiments were not appropriate to estimate the long-term impact of reductions in salt intake.

For the current study we decided to choose a more recent publication from Huang et al.(11) that included 133 studies (n=12197). They estimated that diminishing 50 mmol the 24h urinary sodium excretion resulted in a fall of the SBP by 1,1 mmHg. The duration of the interventions included, differed from <7 days up to >6 months, however, over 60% of total participants attended an intervention >30 days. Although, results from this study seem to indicate that length of the trial was not associated with the change in blood pressure, they did highlight that those interventions under <15 days could underestimate the impact of salt reduction in blood pressure.

We decided to choose the values from Huang et al.(11) because it includes a more recent estimate from more than half participants long-term interventions and additionally, the estimates are even more conservative than previous studies.

Huang et al.(11) reported that a reduction in 50 mmol of sodium (2.92g salt – change in salt excretion) leads to a reduction of 1.1 mmHg in SBP (change in SBP). We assumed a linear continuous regression between salt reduction and SBP levels.

(formula 5)

$$\boxed{\beta = change\ in\ salt\ excretion \times \frac{1}{change\ in\ SBP}}$$

The interquartile range (IQR) for SBP was 135 and 114mmHg based on a national Portuguese survey in adults(6). We considered these IQR to estimate the standard deviation (σ) based on the Cochrane Handbook(72).

(formula 6)

$$\boxed{\sigma = \frac{IQR}{1.35 * (1 - \sqrt{\varepsilon})}}$$

where ε refers to the correlation between SBP and dietary sodium intake which we considered 0.47 as previously proposed by Zhao et al.(18).

Eq. 7 was used to calculate β* based on a study from Norris et al.(73):

(formula 7)

$$\boxed{\beta^* = \frac{\pi}{\sqrt{(3)}\sigma}\beta}$$

Lastly, based on the previous calculations we estimated the relative risk (RR):

(formula 8)

$$\boxed{RR = \exp \beta^*}$$

Estimating baseline and counterfactual values

Based on the individual data of the IAN-AF 2015-16, we made changes to the salt content and food consumption of each food category for each different scenario.

Calculating the potential impact fraction for each scenario

The potential impact fraction (PIF) was calculated by changing the relative risks but keeping the exposure to that category constant. Based on the “RR shift” calculation defined by Barendregt and Veerman(74), we calculated the PIF:

(formula 9)

$$\boxed{\mathrm{PIF} = \frac{\sum_{c=1}^{n} p_c RR_c - \sum_{c=1}^{n} p_c RR_c^*}{\sum_{c=1}^{n} p_c RR_c}}$$

where RR and the RR* is the RR previously calculated and after the intervention, and *P* is the population distribution of exposure (in this case, the five scenarios of Table 1).

For the RR function log-linear function, we used:

(formula 10) $$\boxed{RR = \exp(\log(RR) \text{ x } \boldsymbol{y_{id}})}$$

For Portugal, incidence of hypertension was already available and therefore we did not have to calculate it and we skipped formula 11 for this case. However, because we did not have incidence data available for Spain and Italy, we used the Portuguese incidence (47.3 per 1000 persons-years)(59) and prevalence (36%)(60) of hypertension to estimate the duration of hypertension as a diseases following the formula 11. Based on these calculations, the average duration of hypertension was 7.62 years based on the Portuguese data. Then, for Spain and Italy we estimated the incidence of hypertension (I) in these countries using the prevalence (P) from each country and the duration (d) previously calculated.

(formula 11) $$I = \frac{P}{d}$$

To calculate the number of hypertension cases that would be prevented if the proposed targets were met (*n*), we used:

(formula 12) $$\boxed{n = \text{PIF x } N \text{ x } I}$$

where N is the number of individuals in the population >18 years old (obtained from census data) and I is the incidence calculated in formula 11. The approximate number of cases prevented (*n*) will be calculated for each counterfactual scenario separately.

Results

Table 3 shows salt content at baseline and expected if current policies or future policies proposed by the current study are implemented. It also portraits the "food consumption trend" through changes in availability or sales for the several food categories in 4 years.

Out of the top five contributors to salt intake for each country, three were effectively targeted by salt reduction policies in Spain, two in Portugal and none in Italy. Therefore, for those main contributors that were not targeted, we proposed future policies to reduce their salt content by -16%.

Three foods that were commonly targeted, either by current or future policies, in the three countries were (1) bread, (2) charcuterie and processed meats and, (3) cheeses. At baseline, the country with the highest content of salt for each food was (1) Spain for bread (2.08g salt/100g product), (2) for charcuterie and processed meats it was Portugal (4.38g salt/100g product), and (3) Italy for cheeses (1.3g salt/100g product). The Benchmark of salt in bread expected in 2020 varied from 1g of salt/100g product in Portugal to 1.66g of salt/100g product in Spain, while targets in Italy would remain in the middle (1.14g of salt/100g product). Charcuterie and other processed meats in Italy and Spain would have similar salt limits (2.5 and 2.58g of salt /100g product) while Portugal would be higher at 3.68g salt/100g product, even after a strong reduction of -16%. Cheeses in Spain would have the lowest salt content compared to Italy and Portugal (0.87g salt/100g product vs. 1.09, 1.63, respectively).

The main contributors that differed between countries and were considered for current food reformulation policies were a -10% salt content for ready-to-eat meals in Spain.

As previously mentioned, some of the strategies currently used in Spain and Portugal aimed to reduce salt content also on foods that are not the highest contributors to salt intake. In Spain the categories affected included sauces, canned soups, and salty snacks, with salt reformulation targets to reduce from -6.7% up to -16%. Similarly in Portugal, products targeted were pizzas, breakfast cereals, ready-to-eat meals and chips and other snacks, with policies ranging from -12% to -10%. Furthermore, in Portugal, although vegetable soups have been classified among the top five contributors to salt intake, salt policies have only targeted a small proportion these by reformulating canned soups since in the traditional Portuguese cuisine most soups are consumed fresh and not packaged.

Additionally, future policies suggested in the current study would suppose a -16% reduction of the salt content of fresh meat for Spain, fish for Portugal and in Italy pizza, crackers and salty snacks, and other vegetables.

Overall, an increased availability/purchase of foods most contributing to salt was common for the three countries. Furthermore, some other similarities were found when comparing countries.

Higher availability/sales of charcuterie and other processed meats and, cheeses, occurred in the three countries. For charcuterie and other processed meats, the growth was stronger in Spain compared to Portugal and Italy (+51% vs. +3.02%, +11.50%). Availability/sales of cheeses were very similar for all countries with mildly higher values in Italy compared to Spain and Portugal (+10.94% vs. +10%, +10.83%).

A decrease in the availability/sales of bread was seen in all countries with a stronger intensity in Italy compared to Spain and Portugal (-5.39% vs. -5.00% and -2.86%).

Other categories more specific to each country followed different trends. In Spain, availability increased for ready-to-eat meals (+23.00%), sauces (+19.00%) and canned soups (+2%). While it lowered in categories such as salty snacks (-17.00%) and fresh meat (-2.00%).

In Portugal, sales of pizzas (+36.00%) and chips and other snacks (+10.00%) escalated. However, sales for breakfast cereals (-6.76%) and availability of fresh fish, dry or canned (-3.72%) lowered.

According to Italian data, sales of pizza, crackers and salty snacks reduced by -3.89%, and other vegetables (dry, processed and canned vegetables) increased by +6.44%.

Table 4 shows the impact that the different scenarios would have on salt intake, PIF, hypertension and CV mortality.

According to our results, policies currently implemented in Spain and Portugal could reduce salt intake by -11.1% and -11.2%, respectively, if they were achieved. Furthermore, if future policies were implemented tackling all the top five contributors to salt intake, salt could reduce even more to a maximum of -12.0% in the case of Spain and -13.6% for Portugal. However, scenario 3 shows that if no policies are applied, the food consumption/availability of the foods contributing to salt is likely to increase in the three countries by +12.4% in Spain, +0.1% in Portugal and +1.9% in Italy.

The combination of implementing salt reduction policies and considering the "food consumption trend", corresponding to scenario 4, would lower salt intake by -1.5% in Spain, -13.4% in Portugal and -11.2% in Italy. Furthermore, if the public health campaign of "1 pinch of salt less a day" was promoted, salt intake from scenario 4 could even reduce by an extra -5.7%, -6.9% and -8.5% for Spain, Portugal and Italy, as they follow.

In summary, scenario 5 shows the impact that the overall combination of these factors would lead to, with the strongest impact in Portugal with a total of -24.00%, intermediate in Italy with -17.7% and the weakest in Spain with -7.1%.

Additionally, in the Annex, table S2 describes how salt intake would change according to age and gender for each specific scenario, by country.

In countries where current policies are already implemented, the incidence of hypertension is expected to decrease strongly by -10.99% in Spain and -9.64% in Portugal, preventing 189,915 and 41,123 cases, respectively. Furthermore, the implementation of future policies that we proposed to target the main foods contributing to salt, would decrease the incidence by -8.39% in Italy (N=147,339) to -14.53% in Portugal (N=61,957).

If we did not take into account the salt reduction policies and only considered the "food consumption trend" (scenario 3) both incidence and cases of hypertension would increase for all the countries. Spain would have the strongest impact worsening the incidence of hypertension by +14.68% and increasing 253,532 cases of hypertension per year. The significance would be lower in Portugal with a mild increase of +0.65% of the new cases and increasing 2,780 hypertension cases more, and in Italy with +0.10% and 16,777 cases more.

However, the negative outcomes of the previous scenario are compensated by the implementation of salt reformulation policies. This mitigation is stronger in Portugal with hypertension reducing by -14.04% (N=59,867) compared to Italy, -7.29% (N=128,131), and lowest in Spain, -1.38% (N=23,891). Lastly, the implementation of a public health policy suggested in scenario 5 would have a relevant fall in the incidence and cases of hypertension prevented per year. The Italian population would benefit the most, with a decrease in incidence of -37.35% (N=655,989). Spain would have a smaller change in the incidence of hypertension compared to Portugal (-7.41% vs. -20.23%) but because of the size of the Spanish population, Spain would prevent 128,023 cases of hypertension per year and Portugal 85,767.

The PRIME methodology we used accounted only for changes in salt intake among specific risk factors correlated with NCDs. Furthermore, the model only considered the established association between salt and CV mortality, therefore for these specific results, the prevented total deaths correspond to prevented CV deaths.

Results indicate that salt reformulation strategies currently enforced in Spain and Portugal could be effective at reducing total deaths by -1.55% in Spain (N= 1,388 deaths) and -0.58% in Portugal (N= 728 deaths). Implementing the future policies that we suggested in scenario 2 would even have a stronger impact, preventing from 4,442 deaths in Italy (-2.11% of total deaths, -4.48% of CV deaths) to 3,397 in Spain (-1.67% of total deaths, -4.80% of CV deaths) and 882 deaths in Spain (-1.61% of total deaths, -3.95% of CV deaths).

The "food consumption trend" seems to indicate that all these Southern countries would increase their total deaths and CV deaths, especially those due to hypertensive diseases. Deaths due to CVD would increase by +5.18% for Spain (N= 3,671deaths), +0.04% for Portugal (N= 9 deaths) and +0.72% for Italy (N=715 deaths). Similarly, to the previous results in table 3 the impact of the increasing "food consumption trend" of the main contributors to salt could be reduced by the implementation of policies considered in scenario 4. All countries would benefit from this scenario however, changes in Spain would be moderate, and CV deaths would decrease by -0.62% (N=439 deaths), compared to -3.90% (N= 871 deaths) for the Portuguese population and -4.29% (N=4,250 deaths) for Italy. Aligned with the results from scenario 4, scenario 5 shows the most optimistic results with changes from -2.86% in CV deaths in Spain (N= 2,029 deaths) up to -6.88% in Portugal (N=1.536 deaths) with an intermediate change of -6.69% in Italy (N=6,626 deaths).

Discussion

Our results suggest that the application of food reformulation policies in Southern European countries is not only effective but necessary for the prevention of NCDs and reduction of overall deaths due to CVDs. Food consumption/availability trend of the main contributors to salt intake is increasing in the three Southern Countries indicating that if no policies are applied, incidence of hypertension cases would be expected to increase. However, this situation can be still reverted in all three countries by implementing regulations (including current and future policies) to the salt content of the food products contributing the most to population salt intake. An important consideration is that current policies implemented in Portugal would be sufficient to mitigate the impact of the increasing "food consumption trend", despite of the additional benefit that could be obtained by further policies oriented to the top food contributors to salt intake. However, for Spain the current policies would not be sufficient.

Implementation of food policies alone (considering current policies and implementation of future policies suggested by the current study) without considering the "food consumption trend" could reduce hypertension incidence and CV deaths by -11.85% and -4.80% in Spain, -9.64% and -3.95% in Portugal and, -8.39% and -4.48% in Italy, respectively. If taking into account the changes in consumption according to the trend, the impact would be -1.38% PIF and -0.62% CV deaths in Spain, -14.04% PIF and -3.9% CV deaths in Portugal and, -7.29% PIF and -4.29% CV deaths in Italy. Lastly, the additional implementation of a public health campaign to reduce added salt would achieve a total reduction in new hypertension cases and deaths due CVD of -7.41% and -2.86% for Spain, -20.23% and -6.88% for Portugal and, -37.35% and -6.69% for Italy.

Studies conducted in other countries such as Finland, the United States and Argentina, corroborate the impact of food reformulation policies on lowering blood pressure and reducing CV mortality significantly (75–78). Goiana-da-Silva et al.(79) reported similar outcomes regarding the effectiveness of salt reformulation policies in Portugal. After assessing the impact of salt, sugar and trans-fat reformulation, they found that salt had the strongest impact in reducing NCD mortality.

As previously mentioned, WHO Member States have committed to reduce their salt intake by 30% in 2025 with the aim of achieving <5g/d(80). Hendriksen et al.(81) assessed the impact of these two scenarios i) a reduction of 30% on salt intake among all population, and 2) salt intake being <5 g/day on cardiovascular health, among different European Countries. They reported that in Italy, 103,000 deaths would be averted in the first case and 163,300 for the second. And Spain would have prevented 59,100 and 97,400, respectively(81). However, the research did not include the food consumption/availability trend of the main food products contributing to salt intake.

Our research suggests that food consumption of main contributors to salt intake is increasing and must be taken into account for a better representation of the reality. Based on our most ambitious scenario that assumes effective reformulation, changes in food consumption and additionally a potential public health campaign to reduce “1 pinch of salt a day” would result in a -7.1%, -24.0% and -17,7% of the salt intake in Spain, Portugal and Italy, respectively. Although these numbers are promising, they are unquestionably far from the targets defined. However, regarding the World Health Assembly target of reducing CV deaths and prevalence of hypertension by 25% in 2025. Our results suggest that hypertension objectives might be more realistic since the optimistic scenario we previously mentioned could diminish the incidence of hypertension strongly by -6.17% in Spain, -20.23% in Portugal and -37.35% in Italy.

One aspect to take into consideration is that our current study only evaluated the impact of these strategies on a 4-year period, however, the World Health Assembly defined these targets in 2013 for 2030. Therefore, reinforcing that achieving international goals to reduce the morbidity and mortality of CVD require timely and sustained policies because if applied too late, it is harder to reach the targets.

When considering how to apply future policies, legislative changes might be a better choice to consider. Mandatory regulations for salt reformulation have been described as more effective than voluntary agreements(82–84). However, national policies should work together with the food production industry to facilitate consumer acceptance, a key factor for food reformulation policies as it can become a limitation (75,85,86). For example, when reformulating cheeses to compensate the decrease in sodium, fat content has to be increased which represents an issue for consumers’ acceptability(85). Additionally, we recognise that for cheese, additional guidelines have to be established according to subgroups and regional production as it was done in UK(87). Similarly, although producing charcuterie with lower salt content is challenging, Portugal has the processed meat with the highest values. And previous Spanish policies have already tackled to reduce 16% of salt content in this food category thus, reinforcing that this is possible(88).

Regarding the type of interventions, most research is focused on multiple *upstream* interventions (food reformulation, taxation, and food labelling) suggesting that the biggest changes would be achieved through the implementation of these. While *downstream* policies focused on individual changes (i.e. food labelling, health education, communication campaigns and promotion of healthy environments) are often thought to have less impact(84). However, these *downstream* strategies are not only effective at reducing national salt consumption, increasing knowledge of health risks, and changing behaviours related to salt consumption, but they have been recognised by the WHO as “Best Buys” (31,89,90).

The WHO recommends using comprehensive strategies that combine the two approaches to have a stronger impact on the salt intake of the population. Additionally, their guidelines also stress the importance of monitoring the population salt intake, salt content on foods and impact of salt reduction strategies, to evaluate future strategies(80,90). As suggested by the current results, the future strategies need to take into account the specificities and the different top food contributors to salt intake that could lead to a specific approaches in the different countries.

The current study evaluated the impact of a public health campaign of “1 pinch of salt less a day” that we estimated could lead to a further decrease of the -5.7%, -6.9% and -8.5% of the salt intake in Spain, Portugal, and Italy, as they follow, compared to scenario 4. This initiative could be done through social marketing or promoted in specific settings at national level. For example, in the case of Portugal, soup is considered the second-highest contributor to salt intake and is part of the traditional Portuguese cuisine to eat soup as a first dish. Furthermore, this product is mostly consumed “fresh” (not canned) at home, canteens or in restaurants. Therefore, policies do not intend to reduce consumption of soup, a policy could be proposed to reduce “1 pinch of salt less” when cooking or establishing salt content limits for soups in canteens of schools, workplaces, and hospitals.

The main strength of the current study relies on the fact that this is the first study to 1) evaluate the impact of current food reformulation policies implemented in Spain and Portugal; 2) assess the impact of specific policies on cardiovascular morbidity; 3) consider the “food consumption trend” and 4) consider the covariance between foods in their statistical models. Furthermore, it aims to fill the lack of guidance on public health policies for salt intake in Southern European countries, that could also occur in other European countries. Studies have been conducted in these countries assessing the impact of hypothetical overall salt reductions(81). However, there is the need for more studies assessing the impact of regulations that target specific food categories. Additionally, previous research has mostly focused on estimating the weight on cardiovascular mortality but not morbidity (i.e. hypertension).

Another strength of this study is that we used individual consumption data from Portugal to simulate a more realistic consumption distribution for specific foods for the CV morbidity model. Although consumption distribution and the covariances between foods could not be representative for Spain and Italy, Portugal is a Southern European country that shares some similarities with the other two. Thus, we believe using individual consumption data from the IAN-AF 2015-16 offers a better representation of the differences of consumption between individuals of a same population.

The limitations of this study are mostly due to the weaknesses of comparing country estimates that have used different methodologies to obtain the necessary data of the current impact models. The salt intake was estimated from 24-hour urinary samples of large populations in Spain and Italy. In Portugal we had data from 24-h urinary sodium excretion from an IAN-AF 2015-16 subsample of 95 adults. Therefore, although the sample was small, we corrected for the potential bias on the self-reported estimates adjusting for the misreporting of the real sodium excreted.

Food consumption/availability trend methodologies differed for each country, as previously mentioned. At least two-point individual consumption data would have been the ideal method to estimate trends. However, since this data was not available for the countries, Household Budget Surveys (HBS) were an alternative preferred as opposed to the other sources but they were not available for Portugal during the studied period. Furthermore, although HBS are considered to be representative of available foods at family level (out-of-home food consumption was not accounted for most foods in Spain except for snacks, and for Italy it was unspecified if sales included it), the food categories considered were not standardised and we had to choose unclear categories for Italy (i.e. for processed meats, we chose the “salumi” category which only includes charcuterie, excluding other processed meats). Additionally, HBS in Spain and Italy differed since the latter indicated expenditure which does not only depend on the sales, but price of the food as well (57). For Portugal we considered Food Balance Sheets (FBS) for the main categories(56) however, for specific categories (i.e. canned soups, snacks and chips) we used sales data from Nilsen IQ(53). However, for Portugal we did not have available information from consumption/availability trend for canned soups and ready-to-eat meals (considered in polices) or for fresh vegetable soups (a main contributor of salt intake). Therefore, we assumed that the trend would be stable.

Food consumption of the main contributors to salt intake was assessed differently between countries. In Spain reported estimates were based on a 3-day food diary(44) however for main contributors of salt intake products identified differed from another study that had used a FFQ (91). Unfortunately, because the food consumption data of the FFQ was not published, we lacked data and we decided to use the 3-day food diary study. For Portugal we considered two non-consecutive 24-hour recalls(92) and for Italy a FFQ version more valid than the traditional ones(28). Additionally, only in Portugal discretionary salt was estimated based on the individual consumption data (i.e. considering salt content in traditional recipes)(26), a rough approximation was available for Spain(68) and in Italy it was not assessed. Moreover, for those countries were current food policies targeted specific subcategories we considered the average salt content of all the subproducts and the average salt reduction proposed (i.e. in Spain different reductions were applied to each type of sauce, -16% of salt for mayonnaise, -5% for ketchup). However, because these foods are not important contributors of the diet, we believe they do not compromise the quality of the current study.

Regarding, the studies chosen for the prevalence of national hypertension, harmonisation of different factors was considered a priority, however, heterogeneity of methodologies was common. Among the main issues, sample age ranges included was one of the biggest differences (Italy >18 years old vs. Spain >20 years old vs. Portugal 25-74 years old), followed by age representativeness (>75 years old: Italy 14% vs. Portugal 0%) and measurement of blood pressure (three times in Spain and Portugal vs. undefined in Italy) (7,60,93).

The two models we used for the current study considered some disadvantages. In the case of CV mortality, the PRIME already provides estimates according to sex and age but only considers the impact of salt on CVD, ignoring the association with other NCDs such as cancer. Therefore, total deaths prevented will not be a representation of the reality. For the estimations of impact on hypertension, we were not able to take into account factors such as age, gender, or baseline blood pressure levels, factors that have been identified as strong modifiers of the changes in blood pressure(71). Although some studies suggest that normotensive individuals might not benefit from reductions in salt intake(15), according to Geoffrey Rose, small amounts of change in a large part of the population can lead to significant changes in death rates (94).

In this study we did not consider food substitution models although we recognise, it is an important factor when estimating the health impact of a policy(95).

To estimate the preventable hypertension cases, we ideally needed the incidence for each country to have a better estimation of the new hypertension cases prevented. However, incidence was only available for Portugal. Therefore, for the estimates in the model of Portugal we used the incidence from a population-based cohort study conducted in the north of Portugal(59). For Spain and Italy, we only had prevalence of hypertension values. Because from Portugal we had incidence(59) and prevalence(6) studies available, we decided to use them to calculate the duration of the disease. In this way, with the prevalence studies from each country (Spain and Italy) and the duration of disease calculated, we were able to estimate the incidence for that specific country. However, this strategy had some constraints. Despite the study assessing the incidence of hypertension in the Portuguese population is a population-based and included participants of wide age range, the age representativeness could be a limitation, since proportionally it included more elderly. This could result in a potential overestimation of the real hypertension incidence among the population(59) and in an overestimation of our final results. On the other side, the prevalence study from Portugal was conducted at a national level, using a different population age-range sample compared to the incidence study. Therefore, the duration of the disease calculated based on the Portuguese studies could have been affected by the limitations of the studies used and the difference in the population samples used for each.

Lastly, as mentioned in the methodology, this study assumed a study period from 2016 until 2020 to facilitate the modelling process and the comparability of the results between countries. The limitation we do acknowledge is that we considered baseline numbers in 2016 for some studies (i.e. prevalence and food consumption) that had been carried out some years before. Furthermore, for some specific countries such as Spain, food consumption(44) and sodium intake(24) studies were considered in different populations and at different points in time. Thus, baseline for some categories might be inaccurate since no other data was available. Although we recognise the difficulty of having all the ideal necessary data to complete a study among different countries, the current study provides useful information for stakeholders to rethink and guide future policies.

For future studies, we believe that having at least two-point measurements of individual consumption using standardised methodologies and collected with reasonable periodicity from national representative samples could improve the estimation of trends, especially accounting for the long-term dietary impact of the Covid-19 pandemic. Furthermore, future modelling studies should try to consider the impact of modifiers (i.e. age, gender, ethnicity and blood pressure levels at baseline) on blood pressure changes and take into consideration aspects such as food safety/technical issues, substitution effect or pricing strategies when food reformulation occurs(96).

In conclusion, this study supports with strong evidence that national policies implemented already in countries like Spain and Portugal are effective. However, because consumption of high-salt foods is increasing, they may not be sufficient if they do not target those food categories contributing the most to population salt intake. This highlights that if food policies are not applied at all (in the case of Italy) or not applied to the right food categories (for Spain and Portugal), salt intake will not decrease and might even increase.

Previous studies have not acknowledged the changes in availability and/or sales of the main contributors which might be crucial when assessing the health impact of food reformulation policies. Hence, the impact of future policies must be evaluated before their implementation to ensure that they will be the most cost-effective intervention. When establishing international targets such as the 30% reduction in salt intake defined by WHO, it is also important to evaluate if they are attainable.

Future policies should consider: 1) targeting main contributors to salt intake and either trying to settle agreements with the food industry or establishing mandatory regulations to limit salt content in foods; 2) establishing effective surveillance of salt content in foods and intake of the population and 3) applying comprehensive strategies that combine both *upwards* and *downwards* approaches.

Conflict of Interest

None

Authorship

NLS participated in the conceptualization of the study and collected all relevant data to conduct the statistical analysis. MS conducted the statistical analysis and CL and MJG supported the design and methodological aspects of the study. NLS wrote the first version of the manuscript. MS, MJG and CL revised the manuscript and provided relevant intellectual feedback on the study. All authors read and approved the final manuscript.

References

1. James SL, Abate D, Abate KH, Abay SM, Abbafati C, Abbasi N, et al. Global, regional, and national incidence, prevalence, and years lived with disability for 354 Diseases and Injuries for 195 countries and territories, 1990-2017: A systematic analysis for the Global Burden of Disease Study 2017. The Lancet [Internet]. 2018 Nov 10 [cited 2022 Sep 6];392(10159):1789–858. Available from: http://www.thelancet.com/article/S0140673618322797/fulltext
2. Roth GA, Mensah GA, Johnson CO, Addolorato G, Ammirati E, Baddour LM, et al. Global Burden of Cardiovascular Diseases and Risk Factors, 1990–2019: Update From the GBD 2019 Study. J Am Coll Cardiol. 2020 Dec 22;76(25):2982–3021.
3. Roth GA, Abate D, Abate KH, Abay SM, Abbafati C, Abbasi N, et al. Global, regional, and national age-sex-specific mortality for 282 causes of death in 195 countries and territories, 1980–2017: a systematic analysis for the Global Burden of Disease Study 2017. The Lancet [Internet]. 2018 Nov 10 [cited 2022 Sep 6];392(10159):1736–88. Available from: http://www.thelancet.com/article/S0140673618322037/fulltext
4. Institute for Health Metrics and Evaluation (IHME). Global Burden of Disease 2019. University of Washington. 2022.
5. Banegas JR, Graciani A, de La Cruz-Troca JJ, León-Muñoz LM, Guallar-Castillón P, Coca A, et al. Achievement of cardiometabolic goals in aware hypertensive patients in Spain: a nationwide population-based study. Hypertension [Internet]. 2012 Oct [cited 2022 Sep 7];60(4):898–905. Available from: https://pubmed.ncbi.nlm.nih.gov/22949530/
6. Instituto Nacional de Saúde Doutor Ricardo Jorge. 1o Inquérito Nacional de Saúde com Exame Físico (INSEF 2015): Estado de Saúde. Lisboa; 2016.
7. Tocci G, Nati G, Cricelli C, Parretti D, Lapi F, Ferrucci A, et al. Prevalence and control of hypertension in the general practice in Italy: updated analysis of a large database. J Hum Hypertens [Internet]. 2017 Apr 1 [cited 2022 May 17];31(4):258–62. Available from: https://pubmed.ncbi.nlm.nih.gov/27629243/
8. Strohm D, Boeing H, Leschik-Bonnet E, Arens-Azevêdo U, Bechthold A, Knorpp L. Salt intake in Germany, health consequences, and resulting recommendations for action. A scientific statement from the German Nutrition Society (DGE). Ernahrungs Umschau. 2016;63(03):62–70.
9. Intersalt: an international study of electrolyte excretion and blood pressure. Results for 24 hour urinary sodium and potassium excretion. Intersalt Cooperative Research Group. BMJ [Internet]. 1988 Jul 30 [cited 2022 Aug 6];297(6644):319–28. Available from: https://pubmed.ncbi.nlm.nih.gov/3416162/
10. Whelton PK. Body Weight, Sodium, Potassium, and Blood Pressure. The Journal of Clinical Hypertension [Internet]. 2015 Dec 1 [cited 2022 Aug 6];17(12):926. Available from: /pmc/articles/PMC8031981/
11. Huang L, Trieu K, Yoshimura S, Neal B, Woodward M, Campbell NRC, et al. Effect of dose and duration of reduction in dietary sodium on blood pressure levels: Systematic review and meta-analysis of randomised trials. Vol. 368, BMJ. BMJ Publishing Group; 2020.
12. Filippini T, Malavolti M, Whelton PK, Vinceti M. Sodium Intake and Risk of Hypertension: A Systematic Review and Dose–Response Meta-analysis of Observational Cohort Studies. Curr Hypertens Rep [Internet]. 2022 May 1 [cited 2022

Sep 8];24(5):133–44. Available from: https://link.springer.com/article/10.1007/s11906-022-01182-9

13. Strazzullo P, D'Elia L, Kandala NB, Cappuccio FP. Salt intake, stroke, and cardiovascular disease: Meta-analysis of prospective studies. BMJ (Online). 2009 Nov 25;339(7733):1296.
14. Eckel RH, Jakicic JM, Ard JD, de Jesus JM, Houston Miller N, Hubbard VS, et al. 2013 AHA/ACC guideline on lifestyle management to reduce cardiovascular risk: A report of the American College of cardiology/American Heart Association task force on practice guidelines. Circulation [Internet]. 2014 Jun 24 [cited 2022 Sep 8];129(25 SUPPL. 1):76–99. Available from: https://www.ahajournals.org/doi/abs/10.1161/01.cir.0000437740.48606.d1
15. Graudal N, Hubeck-Graudal T, Jürgens G, Taylor RS. Dose-response relation between dietary sodium and blood pressure: a meta-regression analysis of 133 randomized controlled trials. Am J Clin Nutr [Internet]. 2019 May 1 [cited 2022 Aug 6];109(5):1273–8. Available from: https://academic.oup.com/ajcn/article/109/5/1273/5480600
16. Lennon SL, DellaValle DM, Rodder SG, Prest M, Sinley RC, Hoy MK, et al. 2015 Evidence Analysis Library Evidence-Based Nutrition Practice Guideline for the Management of Hypertension in Adults. J Acad Nutr Diet [Internet]. 2017 Sep 1 [cited 2022 Sep 8];117(9):1445-1458.e17. Available from: http://www.jandonline.org/article/S2212267217303489/fulltext
17. Sacks FM, Svetkey LP, Vollmer WM, Appel LJ, Bray GA, Harsha D, et al. Effects on blood pressure of reduced dietary sodium and the Dietary Approaches to Stop Hypertension (DASH) diet. DASH-Sodium Collaborative Research Group. N Engl J Med [Internet]. 2001 Jan 4 [cited 2022 Sep 8];344(1):3–10. Available from: https://pubmed.ncbi.nlm.nih.gov/11136953/
18. Zhao Q, Gu D, Chen J, Bazzano LA, Rao DC, Hixson JE, et al. Correlation between blood pressure responses to dietary sodium and potassium intervention in a Chinese population. Am J Hypertens [Internet]. 2009 Dec [cited 2022 Jun 10];22(12):1281–6. Available from: https://pubmed.ncbi.nlm.nih.gov/19763120/
19. Brown IJ, Tzoulaki I, Candeias V, Elliott P. Salt intakes around the world: implications for public health. Int J Epidemiol [Internet]. 2009 Jun 1 [cited 2022 May 14];38(3):791–813. Available from: https://academic.oup.com/ije/article/38/3/791/684827
20. European Food Safety Authority. Scientific Committee on Food Scientific Panel on Dietetic Products N and A. Tolerable Upper Intake Levels for Vitamins and Minerals. Opinion of the Scientific Panel on Dietetic Products, Nutrition ad Allergies on a Request from the Commission Related to the Tolerable Upper Intake Level of Sodium [Internet]. Parma; 2006 Feb [cited 2022 May 7]. Available from: https://www.efsa.europa.eu/sites/default/files/efsa_rep/blobserver_assets/ndatolerableuil.pdf
21. Lucko AM, Doktorchik C, Woodward M, Cogswell M, Neal B, Rabi D, et al. Percentage of ingested sodium excreted in 24-hour urine collections: A systematic review and meta-analysis. The Journal of Clinical Hypertension [Internet]. 2018 Sep 1 [cited 2022 Aug 5];20(9):1220–9. Available from: https://onlinelibrary.wiley.com/doi/full/10.1111/jch.13353
22. World Health Organization (WHO). Mapping salt reduction initiatives in the WHO European Region. Copenhagen; 2013.
23. Ortega RM, López-Sobaler AM, Ballesteros JM, Pérez-Farinós N, Rodríguez-Rodríguez E, Aparicio A, et al. Estimation of salt intake by 24 h urinary sodium

excretion in a representative sample of Spanish adults. Br J Nutr [Internet]. 2011 Mar 14 [cited 2022 May 7];105(5):787–94. Available from: https://pubmed.ncbi.nlm.nih.gov/20969815/

24. Partearroyo T, Samaniego-vaesken MDL, Ruiz E. Sodium Intake from Foods Exceeds Recommended Limits in the Spanish Population : The ANIBES Study. Nutrients [Internet]. 2019;11(2451):1–17. Available from: 10.3390/nu11102451
25. Polónia J, Maldonado J, Ramos R, Bertoquini S, Duro M, Almeida C, et al. Estimation of salt intake by urinary sodium excretion in a Portuguese adult population and its relationship to arterial stiffness. Rev Port Cardiol [Internet]. 2006;25(9):801–17. Available from: https://pubmed.ncbi.nlm.nih.gov/17100171/
26. Lopes C, Torres D, Oliveira A, Severo M, Alarcão V, Guiomar S, et al. Inquérito Alimentar Nacional e de Atividade Física (IAN-AF 2015-2016): Relatório de resultados [Internet]. Porto; 2017 [cited 2021 Jan 9]. Available from: https://ian-af.up.pt/sites/default/files/IAN-AF%20Relat%C3%B3rio%20Resultados_0.pdf
27. Goios ACL, Severo M, Lloyd AJ, Magalhães VPL, Lopes C, Torres DPM. Validation of a new software eAT24 used to assess dietary intake in the adult Portuguese population. Public Health Nutr [Internet]. 2020;23(17):3093–103. Available from: https://www-cambridge-org.sire.ub.edu/core/journals/public-health-nutrition/article/validation-of-a-new-software-eat24-used-to-assess-dietary-intake-in-the-adult-portuguese-population/214AE0774CAD55C4E49B286A39342017
28. Malavolti M, Naska A, Fairweather-Tait SJ, Malagoli C, Vescovi L, Marchesi C, et al. Sodium and potassium content of foods consumed in an italian population and the impact of adherence to a mediterranean diet on their intake. Nutrients [Internet]. 2021 Aug 1 [cited 2022 May 17];13(8):2681. Available from: /pmc/articles/PMC8401684/
29. Donfrancesco C, lo Noce C, Russo O, Minutoli D, di Lonardo A, Profumo E, et al. Trend of salt intake measured by 24-h urine collection in the Italian adult population between the 2008 and 2018 CUORE project surveys. Nutrition, Metabolism and Cardiovascular Diseases. 2021 Mar 10;31(3):802–13.
30. World Health Organization. Time to deliver: report of the WHO Independent High-level Commission on Noncommunicable Diseases. [Internet]. Geneva; 2018 [cited 2021 Jan 9]. Available from: https://www.who.int/ncds/management/time-to-deliver/en/
31. World Health Organization. Tackling NCDs: ‘Best buys’ and other recommended interventions for the prevention and control of noncommunicable diseases [Internet]. Geneva; 2017 [cited 2021 Jan 9]. Available from: https://apps.who.int/iris/bitstream/handle/10665/259232/WHO-NMH-NVI-17.9-eng.pdf?sequence=1&isAllowed=y
32. European Commission. Implementation of the EU Salt Reduction Framework - Results of Member States survey [Internet]. Luxembourg; 2012 [cited 2021 Jan 18]. Available from: https://ec.europa.eu/health/sites/health/files/nutrition_physical_activity/docs/salt_report_en.pdf
33. Boletín Oficial Del Estado. Real Decreto 308/2019, de 26 de abril, por el que se aprueba la norma de calidad para el pan. [Internet]. 113 May 11, 2019. Available from: https://www.boe.es/boe/dias/2019/05/11/pdfs/BOE-A-2019-6994.pdf
34. Secretaria-Geral do Ministério da Saúde. Protocolo de Colaboração entre a Direção-Geral da Saúde, o Instituto Nacional de Saúde Doutor Ricardo Jorge, I.P., a Associação dos Industriais de Panificação, Pastelaria e Similares de Lisboa, a Associação dos Industriais de Panificação, Pastelaria e Similares do Norte e a

Associação dos Industriais de Panificação, Pastelaria e Similares. Lisboa, Portugal; 2017.

35. Agencia Española de Seguridad Alimentaria y Nutrición. PLAN de colaboración para la mejora de la composición de los alimentos y bebidas y otras medidas [Internet]. 2020 [cited 2022 May 17]. Available from: https://www.aesan.gob.es/AECOSAN/docs/documentos/nutricion/PLAN_COLABORACION_2020.pdf
36. Direção Geral de Saúde. Programa Nacional para a Promoção da Alimentação Saudável [Internet]. Lisboa; 2019. Available from: https://alimentacaosaudavel.dgs.pt/alimentacao-em-numeros/relatorios-anuais-pnpas/
37. Ministero della Salute. Azioni e progetti del Ministero sul consumo di sale [Internet]. 2018 [cited 2022 May 19]. Available from: https://www.salute.gov.it/portale/temi/p2_6.jsp?lingua=italiano&id=4950&area=stiliVita&menu=alimentazione
38. European Commission. Defining dietary salt and sodium - examples of implemented policies addressing salt reduction | Knowledge for policy [Internet]. [cited 2022 May 21]. Available from: https://knowledge4policy.ec.europa.eu/health-promotion-knowledge-gateway/defining-dietary-salt-sodium-table-6_en
39. Strazzullo P, Cairella G, Campanozzi A, Carcea M, Galeone D, Galletti F, et al. Population based strategy for dietary salt intake reduction: Italian initiatives in the European framework. Nutr Metab Cardiovasc Dis [Internet]. 2012 Mar [cited 2022 Dec 6];22(3):161–6. Available from: https://pubmed.ncbi.nlm.nih.gov/22364888/
40. Hendriksen MAH, van Raaij JMA, Geleijnse JM, Breda J, Boshuizen HC. Health gain by salt reduction in europe: a modelling study. PLoS One [Internet]. 2015 Mar 31 [cited 2022 May 14];10(3). Available from: https://pubmed.ncbi.nlm.nih.gov/25826317/
41. Instituto Nacional de Saúde Doutor Ricardo Jorge. Reduction of salt (sodium) in bread and its contribution to the decrease of blood pressure in Portugal: Health Impact Assessment pilot study-Final report [Internet]. Lisbon (Portugal); 2020 [cited 2022 May 20]. Available from: www.insa.pt
42. Polonia J, Martins L, Pinto F, Nazare J. Prevalence, awareness, treatment and control of hypertension and salt intake in Portugal: Changes over a decade the PHYSA study. J Hypertens [Internet]. 2014;32(6):1211–21. Available from: https://www.sphta.org.pt/files/physastudy_20150506_2.pdf
43. Brussaard J, Löwik M, Steingrímsdóttir L, Møller A, Kearney J, de Henauw S, et al. A European food consumption survey method--conclusions and recommendations. Eur J Clin Nutr [Internet]. 2002 [cited 2022 May 17];56 Suppl 2:S89–94. Available from: https://pubmed.ncbi.nlm.nih.gov/12082521/
44. Partearroyo T, Lourdes D, Ruiz E. Current Food Consumption amongst the Spanish ANIBES Study Population. Nutrients. 2019;11(2663):1–15.
45. Mercasa. Alimentación En España Producción, Industria, Distribución Y Consumo 23ª Edición. 2020/2021 [Internet]. 2020 [cited 2022 Jun 24]. Available from: https://www.mercasa.es/wp-content/uploads/2022/03/AEE_2020_web.pdf
46. Agencia Española de Seguridad Alimentaria y Nutrición. Evaluación Intermedia De Los Acuerdos De Reducción Del Contenido En Nutrientes Seleccionados (Azúcar, Sal Y Grasas) Del Plan De Colaboración Para La Mejora De La Composición De Los Alimentos Y Bebidas Y Otras Medidas 2020. 2020.
47. Pérez-Farinós N, Santos-Sanz S, Dal-Re MÁ, Yusta-Boyo MJ, Robledo T, Castrodeza JJ, et al. Cantidad de sal en el pan en España, 2014. Nutr Hosp [Internet]. 2018 [cited 2022 Dec 7];35(3):650–4. Available from:

https://scielo.isciii.es/scielo.php?script=sci_arttext&pid=S0212-16112018000300650&lng=es&nrm=iso&tlng=en
48. Agencia Española de Consumo y Seguridad Alimentaria y Nutrición. Contenido de sal de los alimentos en España. 2012 [Internet]. Madrid; 2015 [cited 2022 May 7]. Available from: https://www.aesan.gob.es/AECOSAN/docs/documentos/nutricion/estudio_contenido_sal_alimentos.pdf
49. Moreiras O, Carbajal Á, Cabrera L, Cuadrada C. Tablas de Composición de Alimentos. Ediciones. 2013.
50. Lopes C, Torres D, Oliveira A, Severo M, Guiomar S, Alarcão V, et al. National Food, Nutrition, and Physical Activity Survey of the Portuguese General Population (2015-2016): Protocol for Design and Development. JMIR Res Protoc 2018;7(2):e42 https://www.researchprotocols.org/2018/2/e42 [Internet]. 2018 Feb 15 [cited 2022 Dec 5];7(2):e8990. Available from: https://www.researchprotocols.org/2018/2/e42
51. National Institute of Health Dr Ricardo Jorge. Food Composition Table. Lisbon; 2006.
52. Cardoso S, Pinho O, Moreira P, Pena MJ, Alves A, Moreira JL, et al. Salt content in pre-packaged foods available in Portuguese market. Food Control. 2019 Dec 1;106:106670.
53. Ministério da Saúde. Direção-Geral da Saúde. Redução Do Teor De Sal E Açúcar Nos Alimentos | Relatório Do Progresso Da Reformulação Dos Produtos Alimentares Em Portugal 2018-2021. Lisboa; 2022 Feb.
54. Ministerio de Agricultura Pesca y Alimentación. Informe del Consumo Alimentario en España 2020. Madrid; 2021.
55. Ministerio de Agricultura Pesca y Alimentación. Informe del consumo de alimentación en España 2016 [Internet]. Madrid; 2017 Apr [cited 2022 May 7]. Available from: www.mapama.gob.es
56. Instituto Nacional de Estatística. Balança alimentar portuguesa : 2020. Lisboa; 2021.
57. Istituto Nazionale di Statistica. Spese per consumi: Voce di spesa (ECoicop) [Internet]. [cited 2022 Jun 6]. Available from: http://dati.istat.it
58. Ihab R. Definition of hypertension and pressure goals during treatment (ESC-ESH Guidelines 2018). E-Journal of Cardiology Practice [Internet]. 2019 Aug 14 [cited 2022 Aug 19];17(18). Available from: https://www.escardio.org/Journals/E-Journal-of-Cardiology-Practice/Volume-17/definition-of-hypertension-and-pressure-goals-during-treatment-esc-esh-guidelin
59. Pereira M, Lunet N, Paulo C, Severo M, Azevedo A, Barros H. Incidence of hypertension in a prospective cohort study of adults from Porto, Portugal. BMC Cardiovasc Disord [Internet]. 2012;12:114. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3529102/
60. Instituto Nacional de Saúde Doutor Ricardo Jorge. 1º Inquérito Nacional de Saúde com Exame Físico (INSEF 2015): relatório metodológico. [Internet]. Lisboa; 2016 [cited 2022 Jun 6]. Available from: http://repositorio.insa.pt/bitstream/10400.18/3832/3/1_INSEF_relatorio_metodologico.pdf
61. Instituto Nacional de Estatística. Censos 2011 Resultados Definitivos - Portugal. Lisboa; 2012.
62. Istituto Nazionale di Statistica. Popolazione residente al 1° gennaio: Per fascia di età [Internet]. ISTAT. [cited 2022 Jun 10]. Available from: http://dati.istat.it
63. Instituto Nacional de Estadística. Población residente por fecha, sexo y edad [Internet]. INE. [cited 2022 Jun 10]. Available from: https://www.ine.es/

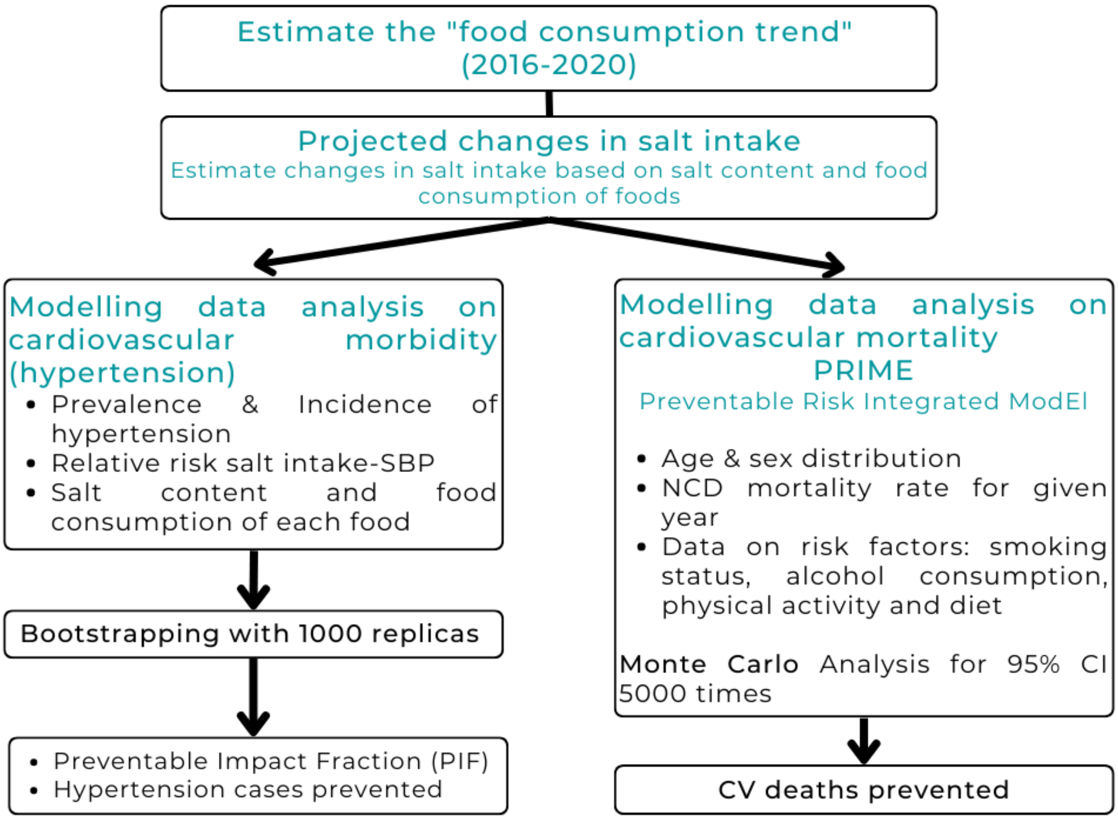
64. Instituto Nacional de Estatística. Causas de Morte: 2017 [Internet]. 2019 [cited 2022 Jun 10]. Available from: https://www.ine.pt/xurl/pub/358633033
65. Istituto Nazionale di Statistica. Mortalità per causa del decesso nel periodo gennaio-giugno 2020 [Internet]. 2022 Apr [cited 2022 Jun 10]. Available from: https://www.istat.it/
66. Instituto Nacional de Estadística. Causa básica de defunción [Internet]. INE. [cited 2022 Jun 10]. Available from: https://www.ine.es/
67. High Level Group on Nutrition and Physical Activity - European Commission. Survey on Members States' Implementation of the EU Salt Reduction Framework [Internet]. 2014 [cited 2022 May 28]. Available from: https://www.aesan.gob.es/AECOSAN/docs/documentos/nutricion/observatorio/encuesta_estados_miembros_sal.pdf
68. Ministerio de Sanidad y Politica Social, Agencia Española de Seguridad Alimentaria y Nutrición. Plan de reducción del consumo de sal. Menos SAL es más SALud. Jornadas de debate [Internet]. La Granja de San Idelfonso ; 2009 Nov [cited 2022 May 21]. Available from: http://eurocarne.com/daal/a1/informes/a2/aesan-reduccion-sal.pdf
69. World Health Organization Regional Office Europe. NCD PRIME. Modelling the impact of national policies on noncommunicable disease (NCD) mortality using PRIME: a policy scenario modelling tool [Internet]. Denmark; 2019 [cited 2021 Jan 23]. Available from: https://www.euro.who.int/__data/assets/pdf_file/0014/411251/PRIME-a-policy-scenario-modelling-tool.pdf
70. Scarborough P, Harrington RA, Mizdrak A, Zhou LM, Doherty A. The Preventable Risk Integrated ModEl and Its Use to Estimate the Health Impact of Public Health Policy Scenarios. Scientifica (Cairo) [Internet]. 2014 [cited 2021 Jan 23];2014:1–21. Available from: /pmc/articles/PMC4195430/?report=abstract
71. He FJ, Li J, MacGregor GA. Effect of longer term modest salt reduction on blood pressure: Cochrane systematic review and meta-analysis of randomised trials. BMJ (Online) [Internet]. 2013;346(7903). Available from: https://pubmed.ncbi.nlm.nih.gov/23558162/
72. Higgins J, Green S. Cochrane Handbook for Systematic Reviews of Interventions: . Wiley Online Library; 2008.
73. Norris CM, Ghali WA, Saunders LD, Brant R, Galbraith D, Faris P, et al. Ordinal regression model and the linear regression model were superior to the logistic regression models. J Clin Epidemiol. 2006 May 1;59(5):448–56.
74. Barendregt JJ, Veerman JL. Categorical versus continuous risk factors and the calculation of potential impact fractions. J Epidemiol Community Health (1978) [Internet]. 2010 Mar [cited 2022 Aug 15];64(3):209–12. Available from: https://pubmed.ncbi.nlm.nih.gov/19692711/
75. Laatikainen T, Pietinen P, Valsta L, Sundvall J, Reinivuo H, Tuomilehto J. Sodium in the Finnish diet: 20-year trends in urinary sodium excretion among the adult population. European Journal of Clinical Nutrition 2006 60:8 [Internet]. 2006 Feb 15 [cited 2022 Jun 12];60(8):965–70. Available from: https://www.nature.com/articles/1602406
76. Karppanen H, Mervaala E. Sodium intake and hypertension. Prog Cardiovasc Dis [Internet]. 2006 Sep [cited 2022 Jun 12];49(2):59–75. Available from: https://pubmed.ncbi.nlm.nih.gov/17046432/
77. Bibbins-Domingo K, Chertow GM, Coxson PG, Moran A, Lightwood JM, Pletcher MJ, et al. Projected Effect of Dietary Salt Reductions on Future Cardiovascular Disease. New England Journal of Medicine [Internet]. 2010 Feb 18 [cited 2022 Jul

16];362(7):590–9. Available from: https://www.nejm.org/doi/full/10.1056/nejmoa0907355
78. Konfino J, Mekonnen TA, Coxson PG, Ferrante D, Bibbins-Domingo K. Projected Impact of a Sodium Consumption Reduction Initiative in Argentina: An Analysis from the CVD Policy Model – Argentina. PLoS One [Internet]. 2013 Sep 9 [cited 2022 Jul 16];8(9). Available from: /pmc/articles/PMC3767589/
79. Goiana-Da-Silva F, Cruz-e-Silva D, Allen L, Gregório MJ, Severo M, Nogueira PJ, et al. Modelling impacts of food industry co-regulation on noncommunicable disease mortality, Portugal. Bull World Health Organ [Internet]. 2019 Jul 1 [cited 2021 Jan 18];97(7):450–9. Available from: http://www.who.int/bulletin/volumes/97/7/18-220566/en/
80. World Health Assembly. Follow-up to the Political Declaration of the High-level Meeting of the General Assembly on the Prevention and Control of Non-communicable Diseases [Internet]. 2013 May [cited 2022 Aug 6]. Available from: https://apps.who.int/gb/ebwha/pdf_files/WHA66/A66_R10-en.pdf?ua=1
81. Hendriksen MAH, van Raaij JMA, Geleijnse JM, Breda J, Boshuizen HC. Health Gain by Salt Reduction in Europe: A Modelling Study. 2015;
82. Gillespie DOS, Allen K, Guzman-Castillo M, Bandosz P, Moreira P, McGill R, et al. The Health Equity and Effectiveness of Policy Options to Reduce Dietary Salt Intake in England: Policy Forecast. PLoS One [Internet]. 2015 Jul 1 [cited 2022 May 20];10(7). Available from: https://pubmed.ncbi.nlm.nih.gov/26131981/
83. Nghiem N, Blakely T, Cobiac LJ, Pearson AL, Wilson N. Health and economic impacts of eight different dietary salt reduction interventions. PLoS One [Internet]. 2015 Apr 24 [cited 2022 May 20];10(4). Available from: https://pubmed.ncbi.nlm.nih.gov/25910259/
84. Hyseni L, Elliot-Green A, Lloyd-Williams F, Kypridemos C, O'Flaherty M, McGill R, et al. Systematic review of dietary salt reduction policies: Evidence for an effectiveness hierarchy? PLoS One [Internet]. 2017 May 1 [cited 2022 May 20];12(5). Available from: /pmc/articles/PMC5436672/
85. Kloss L, Meyer JD, Graeve L, Vetter W. Sodium intake and its reduction by food reformulation in the European Union — A review. NFS Journal. 2015 Jun 1;1:9–19.
86. Hasenegger V, Rust P, König J, Purtscher AE, Erler J, Ekmekcioglu C. Main Sources, Socio-Demographic and Anthropometric Correlates of Salt Intake in Austria. Nutrients [Internet]. 2018 Mar 6 [cited 2022 Jun 12];10(3). Available from: /pmc/articles/PMC5872729/
87. World Health Organization. WHO global sodium benchmarks for different food categories. Geneva; 2021.
88. Agencia Española de Seguridad Alimentaria y Nutrición. Plan 2014 de reducción de sal y grasa en los derivados cárnicos elaborados por los carniceros y charcuteros artesanales. Aecosan [Internet]. 2014 Jul;4–5. Available from: https://www.aesan.gob.es/AECOSAN/docs/documentos/publicaciones/aecosanoticias/AECOSANoticias_37.pdf
89. Dietary Guidelines Advisory Committee. Scientific Report of the 2015 Dietary Guidelines Advisory Committee: Advisory Report to the Secretary of Health and Human Services and the Secretary of Agriculture. Washington, DC; 2015.
90. World Health Organization. The SHAKE Technical Package for Salt Reduction. 2016.
91. Guallar-Castillón P, Muñoz-Pareja M, Aguilera MT, León-Muñoz LM, Rodríguez-Artalejo F. Food sources of sodium, saturated fat and added sugar in the Spanish hypertensive and diabetic population. Atherosclerosis. 2013 Jul;229(1):198–205.

92. Lopes C, Torres D, Oliveira A, Severo M, Alarcão V, Guiomar SJ, et al. Inquérito Alimentar Nacional e de Atividade Física, IAN-AF 2015- 2016: Relatório metodológico. [Internet]. 2017 [cited 2022 Jun 6]. Available from: https://ian-af.up.pt/sites/default/files/IAN-AF%20Relatorio%20Metodol%C3%B3gico.pdf
93. Menéndez E, Delgado E, Fernández-Vega F, Prieto MA, Bordiú E, Calle A, et al. Prevalence, Diagnosis, Treatment, and Control of Hypertension in Spain. Results of the Di@bet.es Study. Rev Esp Cardiol (Engl Ed) [Internet]. 2016 Jun [cited 2022 May 17];69(6):572–8. Available from: https://pubmed.ncbi.nlm.nih.gov/26979767/
94. Manuel DG, Lim J, Tanuseputro P, Anderson GM, Alter DA, Laupacis A, et al. Preventive medicine: Revisiting Rose: strategies for reducing coronary heart disease. BMJ : British Medical Journal [Internet]. 2006 Mar 3 [cited 2022 Sep 9];332(7542):659. Available from: /pmc/articles/PMC1403258/
95. Ibsen DB, Laursen ASD, Wuürtz AML, Dahm CC, Rimm EB, Parner ET, et al. Food substitution models for nutritional epidemiology. Am J Clin Nutr [Internet]. 2021 Feb 2 [cited 2022 Jul 9];113(2):294–303. Available from: https://academic.oup.com/ajcn/article/113/2/294/6029242
96. Afshin A, Sur PJ, Fay KA, Cornaby L, Ferrara G, Salama JS, et al. Health effects of dietary risks in 195 countries, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. The Lancet [Internet]. 2019 May 11 [cited 2022 Sep 8];393(10184):1958–72. Available from: http://www.thelancet.com/article/S0140673619300418/fulltext
97. Ministerio de Consumo, Agencia Española de Seguridad Alimentaria y Nutrición. Informe del Contenido en Sal en los Alimentos 2019 [Internet]. 2021 Aug [cited 2022 Apr 10]. Available from: https://www.aesan.gob.es/AECOSAN/docs/documentos/nutricion/INFORME_reducion_sal_OMS_PLAN_NAOS.pdf
98. World Health Organization. International Classification of Diseases 11th Revision [Internet]. [cited 2022 Sep 12]. Available from: https://icd.who.int/en
99. Barreto M, Gaio V, Antunes L, Rodrigues AP, Kislaya I, Santos AP, et al. Prevalence of Hypertension in Portugal: Results from the First National Health Examination Survey (2015). 9th European Public Health Conference (EPH), 9-12 November 2016 [Internet]. 2016 Nov 11 [cited 2021 Jan 19]; Available from: http://repositorio.insa.pt/handle/10400.18/4351

FIGURES

Figure 1. Methodology structure.



SBP, systolic blood pressure; NCD, non-communicable diseases; PIF, potential impact fraction; CI, confidence intervals; CV, cardiovascular.

TABLES

*Table **1**. Counterfactual Scenarios considered*

Counterfactual Scenario	**Salt reformulation based on**		**Food consumption of food products**	**Added salt**
	Current Policies	**Future Proposed Policies**		
1	Reduced based on goals defined	Assumed stable	Assumed stable	Assumed stable
2	Reduced based on goals defined	Reduced based on goals defined	Assumed stable	Assumed stable
3	Assumed stable	Assumed stable	Changed according to "food consumption trend" estimations	Assumed stable
4	Reduced based on goals defined	Reduced based on goals defined	Changed according to "food consumption trend" estimations	Assumed stable
5	Reduced based on goals defined	Reduced based on goals defined	Changed according to "food consumption trend" estimations	Reduction of 1 pinch of salt (considering each pinch of salt to be of 0.36g)

In yellow those categories that were not assumed stable.

*Table **2**. Salt reduction policies considered for the counterfactual scenarios*

	SPAIN			PORTUGAL			ITALY		
	Defined by	**Food category**	**Salt target (g salt/100g)**	**Defined by**	**Food category**	**Salt target (g salt/100g)**	**Defined by**	**Food category**	**Salt target (g salt/100g)**
Current Policies (Scenario 1)	AECOSAN(35)	Sausages and other processed meats	-16% (2017-2020)	The government(34)	Bread and "tostas"	<1 (2021)	-	-	-
		Sauces*		PNPAS(36)	Ready-to-eat meals	<0.3 (2023)			
		Canned soups	-6.7% (2017-2020)		Pizzas	-10% (2019-2022)			
		Ready-to-eat meals	-10% (2017-2020)		Breakfast cereals				
		Salty snacks*	-13.8% (2017-2020)		Canned soups	<0.3 (2023)			
	Legislative change(33)	Bread	<1.31 (2022)		Chips and other snacks	-12% (2019-2022)			
Future Policies proposed (Scenario 2)	Based on EC recommendations(67)	Cheese	-10% (2016-2020)	Based on EC(67) and former Spanish policies(88)	Charcuterie and other processed meats	-16% (2016-2020)	Based on EC recommendations(67)	Bread and rolls	-16% (2016-2020)
								Processed meat	
								Pizza, crackers and salty snacks	
		Fresh meat	-10% (2016-2020)	Based on EC recommendations(67)	Fresh fish, dry or canned	-16% (2016-2020)		Cheese	
					Cheese			Other vegetables	

*Although specific salt targets have been defined for foods within these categories, this study considered the overall reduction proposed for the general food category.

†Agreements have been established with the industry in Italy but no monitoring data of the reformulation effectiveness has been published and the salt content study we considered provides values from 2016 (after the theoretical reformulation timeline of 2010-2012). Because we did not know if the salt content in bread of 2016 is the result of the reformulation or not, we assumed that the reformulation had not occurred. Therefore, for Italy we only considered the proposed future policies.

Table 3. Baseline and projected values for salt content and "food consumption trend" (2016-2020) considered in the models for Spain, Portugal and Italy.

COUNTRY	**Food Category**	**Salt Content (g salt/100g product or %salt reduction)**			**"Food consumption trend"**		
Spain		Policy	Baseline content	Expected content	Average Annual Food Consumption/availability (kg/pers/year) (54,55)		Trend of 4 years (%) (2016-20)
			2016	2020	2016	2020	
	Sausages & other processed meats	-16%(35)	2.98(97)	2.56	8.23	12.39	+50.55%
	Sauces[+]	-16%(35)	1.65(35)	1.39	2.60	3.09	+18.85%
	Canned soups	-6.7%(35)	0.75(35)	0.7	99.80	101.60	+1.80%
	Ready-to-eat meals	-10%(35)	1.36 (97)	1.17	13.70	16.85	+22.99%
	Salty snacks[+]	-13.8%(35)	1.66 (35)	1.43	1.84	1.53	-16.85%
	Bread	<1.66(33)	2.08(47)	1.66	34.65	32.78	-5.40%
	Cheese	-16%(67)	1.04(48)	0.87	8.02	8.80	+9.73%
	Fresh meat		0.16(49)	0.13	37.11	36.20	-2.45%
Portugal	Food category	Policy	Baseline content	Expected content	Sale of products (kg/year) (53)		Trend of 4 years (%) (2016-2020)(56)*
			2016	2020	2018	2020	
	Bread and "tostas"	≤ 1g(34)	1.33(26)	1.0	-	-	-2.86%
	Canned soups	<0.3g(36)	0.70(52)	0.30	-	-	-
	Ready-to-eat meals	<0.9g(36)	-	0.90	-	-	-
	Pizzas	-10%(36)	1.78(53)	1.38	8,739,171	11,006,271	+36%
	Breakfast cereals	-10%(36)	0.71(53)	0.60	16,503,001	14,633,223	-6.76%
	Chips and other snacks	-12%(36)	1.25(53)	1.13	12,744,278	13,635,859	+10%
	Charcuterie and other processed meats	-16%(67,88)	4.38(26)	3.68	-	-	+3.02%
	Fresh fish. dry or canned	-16%(67)	1.29(26)	1.09	-	-	-3.72%
	Cheeses		1.94(26)	1.63	-	-	+10.83%
Italy	Food category	Policy	Baseline content	Expected content	Monthly family expenditure (€)(57)†		Trend of 4 years (%) (2016-2020)
			2016	2020	2016	2020	
	Bread and rolls	-16%(67)	1.34(28)	1.14	23.02	21.78	-5.39%
	Processed meat		2.98(28)	2.5	23.21	25.88	+11.50%

	Pizza. crackers and salty snacks		1.54(28)	1.29	5.66	5.44	-3.89%
	Cheese		1.30(28)	1.09	29.17	32.36	+10.94%
	Other vegetables		0.97(28)	0.81	15.52	16.52	+6.44%

"Food consumption trend" refers to changes in availability or sales for the several food categories through time. In green, current policies, and in orange, future policies suggested by the current study. * Data was only available for the difference between the two years. General categories were considered: (1) cereal grains, (3) meat, (4) fish, (5) cheeses. The food consumption of soup was not estimated because of lack of data on this specific dish and its importance in the Portuguese culture. Thus, for the calculations we assumed the soup consumption was stable during this period of time. †The following categories were considered: (1) Bread; (2) charcuterie; (3) the average trend was calculated from the two categories separately (pizza; cracker and salty snacks); (4) cheese and dairy products; (5) dry, processed or canned vegetables.

Table 4. Impact in salt change, potential impact fraction (PIF), hypertension cases and cardiovascular mortality for each scenario in Spain, Portugal and Italy.

Country		**Change in salt intake***	**PIF**	**Cases of HT prevented n (95% CI)**	**CV deaths prevented**	
					N° of deaths prevented n (95% CI)	% change†
Spain	**Scenario 1**	-11.09%	10.99% (10.85% – 11.18%)	189,915 (187,334 – 193,030)	3,155 (1,388–4,888)	-4.46%
	Scenario 2	-11.96%	11.85% (11.69% – 12.04%)	204,735 (201,932 – 207,972)	3,397 (1,433–5,207)	-4.80%
	Scenario 3	+12.40%	-14.68% (-15.10 – -14.34%)	-253,532 (-260,892 – -247,765)	-3,671 (-5,797– -1,496)	+5.18%
	Scenario 4	-1.50%	1.38% (1.23 – 1.54%)	23,891 (21,218 – 26,516)	439 (195–679)	-0.62%
	Scenario 5	-7.07%	7.42% (7.20% – 7.66%)	128,023 (124,318 – 132,291)	2,029 (837–3,173)	-2.86%
Portugal	**Scenario 1**	-11.16%	9.64% (9.11% – 10.11%)	41,123 (38,846 – 43,100)	728 (320–1,148)	-3.26%
	Scenario 2	-13.57%	14.53% (13.92% – 15.11%)	61,957 (59,359 – 64,431)	882 (381–1,371)	-3.95%
	Scenario 3	0.12%	-0.65% (-0.80% – -0.05%)	-2,780 (-3,424 – -2,104)	-9 (-14– -3)	+0.04%
	Scenario 4	-13.40%	14.04% (13.46% – 14.64%)	59,867 (57,379 – 62,408)	871 (373–1,361)	-3.90%
	Scenario 5	-23.99%	20.23% (19.39% – 21.25%)	86,240 (82,679 – 90,589)	1,536 (663–2,359)	-6.88%
Italy‡	**Scenario 1**					
	Scenario 2	-11.75%	8.39% (8.27% – 8.49%)	147,339 (145,207 – 149,112)	4,442 (1,978 – 6,848)	-4.48%
	Scenario 3	1.92%	-0.10% (-1.00% – -0.09%)	-16,777 (-17,624 – -15,816)	-715 (-1,144 – -295)	+0.72%
	Scenario 4	-11.23%	7.29% (7.15% – 7.40%)	128,131 (125,617 – 129,971)	4,250 (1,818 – 6,611)	-4.29%
	Scenario 5	-17.73%	37.35% (37.04% – 37.63%)	655,989 (650,537 – 660,926)	6,626 (2,893 – 10,314)	-6.69%

Values reported correspond to mean (95% CI) calculated running the Monte Carlo analysis 5000 times. CVDs, Cardiovascular Diseases. *Salt intake change is the relative difference between salt intake at baseline and expected for each scenario. †Change in deaths refers to the relative difference between cardiovascular deaths at baseline and expected for each scenario. ‡Within cardiovascular deaths, Italian data for deaths due to aortic aneurysm, pulmonary embolism and rheumatic heart disease was not available thus, baseline values were calculated using Spanish data and making it proportional to the size of the Italian population(98)

SUPPLEMENTARY TABLES

Table S1. Summary of data sources of data considered in the models

Source for	Spain		Portugal		Italy
Prevalence of HT	Achievement of Cardiometabolic Goals in Aware Hypertensive Patients in Spain: A Nationwide Population-Based Study(5)		INSEF. Prevalence of Hypertension in Portugal: Results from the First National Health Examination Survey(99)		Prevalence and control of hypertension in the general practice in Italy: updated analysis of a large database (2017)(7)
Sodium intake	Estimation of salt intake by 24 h urinary sodium excretion in a representative sample of Spanish adults(23)		IAN-AF (2015-16). Inquérito Alimentar Nacional e de Atividade Física(26)		Trend of salt intake measured by 24-h urine collection in the Italian adult population between the 2008 and 2018 CUORE project surveys (2021)(29)
Main food contributors to salt intake	Sodium Intake from Foods Exceeds Recommended Limits in the Spanish Population: the ANIBES Study (2019)(24)		Validation of a new software eAT24 used to assess dietary intake in the adult Portuguese population(27)		Sodium and Potassium Content of Foods Consumed in an Italian Population and the Impact of Adherence to a Mediterranean Diet on Their Intake (2021)(28)
Food consumption of main contributors	Current Food Consumption amongst the Spanish ANIBES Study Population(44)		IAN-AF (2015-16). Inquérito Alimentar Nacional e de Atividade Física(26) Balança Alimentar Portuguesa (2016-20)(56)		
Food consumption/availability trend	Informe del Consumo de Alimentación en España 2016, 2020(54,55)				Spese per consumi: Voce di spesa (Ecoicop) (2016-2020)(57)
Salt content of main contributors across several years	Bread	Cantidad de sal en el pan en Espana(33)	Bread; (28)cuterie and other processed meats; fresh fish, dry or canned and c(49)es	IAN-AF (2015-16). Inquérito Alimentar Nacional e de Atividade Física(26)	Sodium and Potassium Content of Foods Consumed in an Italian Population and(48) Impact of Adherence to a
	Cheese	Contenido de sal de los alimentos en España 2012(48)			
	Fresh meat	Tablas de Composición de Alimentos (Moreiras) 2013(49)			

	Sausages & other processed meats and ready-to-eat meals	Informe del contenido en sal en los alimentos 2019(97)	Pizzas, breakfast cereals, chips and other snacks	Redução Do Teor De Sal E Açúcar Nos Alimentos | Relatório Do Progresso Da Reformulação Dos Produtos Alimentares Em Portugal 2018-2021(53)	Mediterranean Diet on Their Intake (2021)(28)
	Sauces, salty snacks and canned soups	PLAN de colaboración para la mejora de la composición de los alimentos y bebidas y otras medidas(35)	Canned soups	Salt content in pre-packaged foods available in Portuguese market(52)	

Table S2. Projected daily salt intake (g/day)

COUNTRY	**Gender and age**	Salt intake (g/d)													
		Baseline		**Baseline with Corrections**		**Scenario 1**		**Scenario 2**		**Scenario 3**		**Scenario 4**		**Scenario 5**	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
SPAIN[23]	**M&F 15-19**	9.54	4.61			8.48	4.61	8.40	4.61	10.72	4.61	9.40	4.61	8.87	4.61
	M&F 20-24	9.54	4.61			8.48	4.61	8.40	4.61	10.72	4.61	9.40	4.61	8.87	4.61
	M&F 25-29	9.54	4.61			8.48	4.61	8.40	4.61	10.72	4.61	9.40	4.61	8.87	4.61
	M&F 30-34	10.11	4.61			8.99	4.61	8.90	4.61	11.36	4.61	9.96	4.61	9.40	4.61
	M&F 35-39	10.11	4.61			8.99	4.61	8.90	4.61	11.36	4.61	9.96	4.61	9.40	4.61
	M&F 40-44	10.46	4.79			9.30	4.79	9.21	4.79	11.76	4.79	10.30	4.79	9.72	4.79
	M&F 45-49	10.46	4.79			9.30	4.79	9.21	4.79	11.76	4.79	10.30	4.79	9.72	4.79
	M&F 50-54	9.51	4.46			8.46	4.46	8.37	4.46	10.69	4.46	9.37	4.46	8.84	4.46
	M&F 55-59	9.51	4.46			8.46	4.46	8.37	4.46	10.69	4.46	9.37	4.46	8.84	4.46
	M&F 60-64	9.51	4.46			8.46	4.46	8.37	4.46	10.69	4.46	9.37	4.46	8.84	4.46
	M&F 65-69	9.51	4.46			8.46	4.46	8.37	4.46	10.69	4.46	9.37	4.46	8.84	4.46
	M&F 70-74	9.51	4.46			8.46	4.46	8.37	4.46	10.69	4.46	9.37	4.46	8.84	4.46
	M&F 75-79	9.51	4.46			8.46	4.46	8.37	4.46	10.69	4.46	9.37	4.46	8.84	4.46
	M&F 80-84	9.51	4.46			8.46	4.46	8.37	4.46	10.69	4.46	9.37	4.46	8.84	4.46
	M&F 85+	9.51	4.46			8.46	4.46	8.37	4.46	10.69	4.46	9.37	4.46	8.84	4.46
PORTUGAL[26]	**M15-19**	8.50	2.40	9.79	2.40	8.69	2.40	8.46	2.40	9.80	2.40	8.47	2.40	7.44	2.40
	M20-24	8.90	2.40	10.19	2.40	9.05	2.40	8.80	2.40	10.20	2.40	8.82	2.40	7.74	2.40
	M25-29	9.10	2.50	10.39	2.50	9.23	2.50	8.98	2.50	10.40	2.50	8.99	2.50	7.89	2.50
	M30-34	9.20	2.50	10.49	2.50	9.31	2.50	9.06	2.50	10.50	2.50	9.08	2.50	7.97	2.50
	M35-39	9.30	2.50	10.59	2.50	9.40	2.50	9.15	2.50	10.60	2.50	9.17	2.50	8.05	2.50
	M40-44	9.30	2.50	10.59	2.50	9.40	2.50	9.15	2.50	10.60	2.50	9.17	2.50	8.05	2.50
	M45-49	9.30	2.50	10.59	2.50	9.40	2.50	9.15	2.50	10.60	2.50	9.17	2.50	8.05	2.50
	M50-54	9.10	2.50	10.39	2.50	9.23	2.50	8.98	2.50	10.40	2.50	8.99	2.50	7.89	2.50
	M55-59	9.00	2.50	10.29	2.50	9.14	2.50	8.89	2.50	10.30	2.50	8.91	2.50	7.82	2.50
	M60-64	8.70	2.40	9.99	2.40	8.87	2.40	8.63	2.40	10.00	2.40	8.65	2.40	7.59	2.40
	M65-69	8.40	2.40	9.69	2.40	8.60	2.40	8.37	2.40	9.70	2.40	8.39	2.40	7.36	2.40
	M70-74	8.10	2.40	9.39	2.40	8.34	2.40	8.11	2.40	9.40	2.40	8.13	2.40	7.13	2.40
	M75-79	7.70	2.20	8.99	2.20	7.98	2.20	7.77	2.20	9.00	2.20	7.78	2.20	6.83	2.20
	M80-84	7.20	2.10	8.49	2.10	7.54	2.10	7.33	2.10	8.50	2.10	7.35	2.10	6.45	2.10
	M85+	7.20	2.10	8.49	2.10	7.54	2.10	7.33	2.10	8.50	2.10	7.35	2.10	6.45	2.10
	F15-19	6.80	1.80	8.09	1.80	7.18	1.80	6.99	1.80	8.09	1.80	7.00	1.80	6.15	1.80

	F20-24	6.80	1.80	8.09	1.80	7.18	1.80	6.99	1.80	8.09	1.80	7.00	1.80	6.15	1.80
	F25-29	6.70	1.80	7.99	1.80	7.09	1.80	6.90	1.80	7.99	1.80	6.92	1.80	6.07	1.80
	F30-34	6.60	1.80	7.89	1.80	7.01	1.80	6.82	1.80	7.89	1.80	6.83	1.80	5.99	1.80
	F35-39	6.60	1.80	7.89	1.80	7.01	1.80	6.82	1.80	7.89	1.80	6.83	1.80	5.99	1.80
	F40-44	6.50	1.80	7.79	1.80	6.92	1.80	6.73	1.80	7.79	1.80	6.74	1.80	5.92	1.80
	F45-49	6.40	1.70	7.69	1.70	6.83	1.70	6.64	1.70	7.69	1.70	6.66	1.70	5.84	1.70
	F50-54	6.40	1.70	7.69	1.70	6.83	1.70	6.64	1.70	7.69	1.70	6.66	1.70	5.84	1.70
	F55-59	6.30	1.70	7.59	1.70	6.74	1.70	6.56	1.70	7.59	1.70	6.57	1.70	5.77	1.70
	F60-64	6.20	1.70	7.49	1.70	6.65	1.70	6.47	1.70	7.49	1.70	6.48	1.70	5.69	1.70
	F65-69	6.20	1.70	7.49	1.70	6.65	1.70	6.47	1.70	7.49	1.70	6.48	1.70	5.69	1.70
	F70-74	6.10	1.60	7.39	1.60	6.56	1.60	6.38	1.60	7.39	1.60	6.40	1.60	5.61	1.60
	F75-79	6.00	1.70	7.29	1.70	6.47	1.70	6.30	1.70	7.29	1.70	6.31	1.70	5.54	1.70
	F80-84	6.00	1.60	7.29	1.60	6.47	1.60	6.30	1.60	7.29	1.60	6.31	1.60	5.54	1.60
	F85+	6.00	1.60	7.29	1.60	6.47	1.60	6.30	1.60	7.29	1.60	6.31	1.60	5.54	1.60
ITALY(29)	**M15-19**	9.53	3.88					8.41	3.88	9.71	3.88	8.46	3.88	7.84	3.88
	M20-24	9.53	3.88					8.41	3.88	9.71	3.88	8.46	3.88	7.84	3.88
	M25-29	9.53	3.88					8.41	3.88	9.71	3.88	8.46	3.88	7.84	3.88
	M30-34	9.53	3.88					8.41	3.88	9.71	3.88	8.46	3.88	7.84	3.88
	M35-39	9.53	3.88					8.41	3.88	9.71	3.88	8.46	3.88	7.84	3.88
	M40-44	9.53	3.88					8.41	3.88	9.71	3.88	8.46	3.88	7.84	3.88
	M45-49	9.82	3.71					8.67	3.71	10.01	3.71	8.72	3.71	8.08	3.71
	M50-54	9.82	3.71					8.67	3.71	10.01	3.71	8.72	3.71	8.08	3.71
	M55-59	9.59	3.53					8.46	3.53	9.77	3.53	8.51	3.53	7.89	3.53
	M60-64	9.59	3.53					8.46	3.53	9.77	3.53	8.51	3.53	7.89	3.53
	M65-69	9.53	3.47					8.41	3.47	9.71	3.47	8.46	3.47	7.84	3.47
	M70-74	9.53	3.47					8.41	3.47	9.71	3.47	8.46	3.47	7.84	3.47
	M75-79	9.53	3.47					8.41	3.47	9.71	3.47	8.46	3.47	7.84	3.47
	M80-84	9.53	3.47					8.41	3.47	9.71	3.47	8.46	3.47	7.84	3.47
	M85+	9.53	3.47					8.00	3.47	9.71	3.47	8.46	3.47	7.84	3.47
	F15-19	7.12	2.76					6.28	2.76	7.26	2.76	6.32	2.76	5.86	2.76
	F20-24	7.12	2.76					6.28	2.76	7.26	2.76	6.32	2.76	5.86	2.76
	F25-29	7.12	2.76					6.28	2.76	7.26	2.76	6.32	2.76	5.86	2.76
	F30-34	7.12	2.76					6.28	2.76	7.26	2.76	6,32	2.76	5.86	2.76
	F35-39	7.12	2.76					6.28	2.76	7.26	2.76	6.32	2.76	5.86	2.76
	F40-44	7.12	2.76					6.28	2.76	7.26	2.76	6.32	2.76	5.86	2.76
	F45-49	7.24	2.76					6.39	2.76	7.38	2.76	6.43	2.76	5.96	2.76
	F50-54	7.24	2.76					6.39	2.76	7.38	2.76	6.43	2.76	5.96	2.76

	F55-59	7.65	3.24					6.75	3.24	7.80	3.24	6.79	3.24	6.29	3.24
	F60-64	7.65	3.24					6.75	3.24	7.80	3.24	6.79	3.24	6.29	3.24
	F65-69	7.12	2.71					6.28	2.71	7.26	2.71	6.32	2.71	5.86	2.71
	F70-74	7.12	2.71					6.28	2.71	7.26	2.71	6.32	2.71	5.86	2.71
	F75-79	7.12	2.71					6.28	2.71	7.26	2.71	6.32	2.71	5.86	2.71
	F80-84	7.12	2.71					6.28	2.71	7.26	2.71	6.32	2.71	5.86	2.71
	F85+	7.12	2.71					6.28	2.71	7.26	2.71	6.32	2.71	5.86	2.71

M= Males; F=Females. Values in red were assumed as the previous/posterior category