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High Salt Intake in India: Health and Economic Impacts

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Abstract - India has one of the highest salt intakes in the world, with average consumption around 11 grams per day according to systematic reviews. This exceeds the WHO recommended limit of less than 6 grams per day for adults and has major implications for population health. High salt intake is a major risk factor for elevated blood pressure, which increases the risk of cardiovascular diseases including heart attacks and strokes. These conditions account for over a quarter of deaths in India and are major contributors to healthcare costs and productivity losses. The economic impacts are substantial, with research projections suggesting India could lose $2 trillion from 2012-2030 due to hypertension and associated diseases attributable to high salt intake. Regional data shows some variations in intake, but overall levels remain dangerously high across the country. Strategies are urgently needed to reduce population-level sodium consumption. These include product reformulation, consumer education, front-of-pack labelling, taxation of high-salt foods, and collaborative engagement with the food industry. Some progress has been made through initiatives like the Food Safety and Standards Authority of India's work to establish maximum sodium levels for various food categories. However, bolder policy action and multi-sectoral partnerships are essential to make meaningful change. Any reduction in mean population salt intake could have tremendous benefits. A 3 gram decline could potentially avert 5.8 million strokes and heart attacks over 10 years, while a 5 gram reduction could avert 13.8 million. Alongside lowering cardiovascular risk, this would generate substantial healthcare savings and productivity gains. The economic case for accelerated action is compelling, given the immense costs of inaction outlined by the WHO. Population-based approaches including product reformulation and consumer education campaigns have achieved major sodium reduction in other countries, demonstrating this is an achievable goal for India as well. Urgent steps must be taken to make low sodium diets the default for Indians to gain health benefits and mitigate the projected $2 trillion economic burden.

Keywords: Sodium, Hypertension, Cardiovascular disease, Stroke, Reformulation, Packaged foods, Home cooking, Seasoning, Public health, Policy.

1. INTRODUCTION

1.1 Background on High Salt Consumption in India

India has one of the highest salt intakes globally, with average consumption estimated to be around 11 grams per person per day. This level of dietary sodium places India among the countries with the most elevated intakes worldwide. It far exceeds the World Health Organization's recommended limit of under 6 grams of salt per day for adults. High salt consumption has become a major public health concern in India due to its well-established links to elevated blood pressure and increased risks of cardiovascular diseases.

The main source of sodium in Indian diets is added salt, accounting for around 76% of total intake. This reflects heavy use of salt in home cooking, as well as frequent consumption of salty snacks and processed foods. Regional cuisine and taste preferences have contributed to normalized behaviors of adding salt

liberally during meal preparation and eating. Analyses of typical Indian meal plans indicate sodium levels two to five times higher than other Asian country averages. For instance, a standard North Indian lunch containing dal, rice, vegetables, yogurt, and papad was found to provide 5 grams of salt alone.

Cultural and socioeconomic factors further enable high salt intake. Serving salty foods is seen as desirable hospitality. Lower income households depend more on low-cost cereals and added salt for flavor in place of more expensive spices, nuts, fruits. Affordable, convenient packaged snacks and fast foods tend to be high in sodium as well. Traditional beliefs also encourage salt consumption, such as the view that salt aids digestion.

Rising processed food consumption has been another key driver of excessive sodium intake. Indian packaged food and restaurant items frequently contain very high amounts. A 2017 study found average sodium levels ranging from 1500-4000mg per 100g in categories like chips, instant noodles, traditional snacks, breads, soups, and savory mixes. Such products are growing in popularity with India's urbanization and lifestyle changes. Aggressive marketing and incorrect consumer perception that packaged foods are safe or hygienic also promote intake.

Government efforts to reduce salt use have achieved limited impacts to date. Initiatives like the Food Safety and Standards Authority of India (FSSAI) voluntary framework for sodium reduction in processed foods have made some progress in engagement with industry, but compliance remains low. Mandatory sodium limits for processed foods proposed in draft regulations have faced opposition. Public education activities like Salt Awareness Week have raised visibility but lack scale. Integrated policies tackling production, supply, and demand are still needed.

The high disease burden attributed to excessive salt intake makes this a critical public health and economic issue. Cardiovascular diseases are the leading cause of mortality in India, responsible for over a quarter of deaths. High blood pressure affects nearly 1 in 4 Indian adults. While multiple factors contribute to these epidemics, high sodium intake has been identified as a major modifiable risk factor. Comprehensive strategies to reduce population-level salt consumption are urgently required as part of efforts to prevent cardiovascular morbidity and mortality.

1.2 Health Risks of High Sodium Intake

High sodium intake is a well-established risk factor for elevated blood pressure and adverse cardiovascular health outcomes. The causal link between high salt consumption and hypertension has been demonstrated in many rigorous studies including dose-response meta-analyses, population-based cohort studies, and randomized controlled trials of sodium reduction. There is overwhelming evidence that decreasing sodium intake reduces blood pressure in both hypertensive and normotensive individuals. Even modest reductions in salt consumption can have significant impacts on population blood pressure levels.

Raised blood pressure is in turn a leading risk factor for cardiovascular diseases, especially heart attacks and strokes. Long-term excessive sodium intake causes sustained increases in blood pressure, inducing structural changes in blood vessels that exacerbate atherosclerosis, enlarge the heart muscle, and increase cardiac strain. This substantially raises risks of ischemic heart disease, congestive heart failure, cardiac arrhythmias, and other vascular pathologies over time. The burden of hypertension-related cardiovascular disease is immense, contributing to over 10 million deaths globally each year.

Beyond effects on blood pressure, high salt intake has also been linked to other adverse outcomes. Evidence from clinical and animal studies indicates it can induce left ventricular hypertrophy, worsening of renal function, proteinuria, stiffness of conduit arteries, and thickness of the carotid wall. These changes are key precursors of progressive cardiovascular damage. High sodium consumption may also have pro-oxidative and fibrotic effects, further amplifying risks. Additionally, diets high in salt are associated with greater stomach cancer risk. Proposed mechanisms include damage to gastric mucosa and alterations in Helicobacter pylori pathogenicity. High sodium intake has been correlated with higher risk of gastric cancer in population studies. Randomized trials found reducing salt intake decreased gastric cancer incidence and mortality, underscoring the causative relationship.

Excessive sodium has also been linked to potential harms for bone and calcium homeostasis. It increases urinary calcium excretion, possibly predisposing to osteoporosis over the long term. However, evidence for tangible impacts on bone mineral density and fracture risk remains inconclusive at a population level. Certain subgroups are at greater risk from the effects of high salt intake. Older adults, individuals with diabetes or chronic kidney disease, and those with established cardiovascular disease tend to be more sodium sensitive. Blood pressure effects are amplified in these patients, highlighting the importance of moderating sodium for secondary prevention. Genetic factors may also confer greater susceptibility in salt-sensitive individuals.

Overall, the consistent evidence on adverse cardiovascular outcomes provides more than sufficient grounds for public health action. Even small downward shifts in population sodium intake could yield substantial benefits. A 3 gram per day reduction is projected to potentially prevent 5.8 million cardiovascular events over 10 years in India alone. There is consensus among leading health authorities that current intakes are far too high and must be lowered through comprehensive strategies targeting dietary sources. Alongside reducing hypertension, this promises immense positive impacts on mortality and morbidity from heart disease and stroke.

1.3 Economic Burden of Hypertension and Cardiovascular Disease Associated With High Salt Intake

The high costs of healthcare utilization and productivity losses attributed to hypertension and cardiovascular diseases linked to excessive salt consumption impose a tremendous economic burden worldwide. In India, where average population sodium intake is around 11 grams per day, the impacts on health spending and national income are immense. Reducing salt consumption has been identified as a cost-effective strategy that could potentially avert millions of cardiovascular events and yield billions of dollars in economic gains.

According to WHO, high blood pressure is the leading single contributor globally to mortality and burden of disease as measured in disability-adjusted life years (DALYs). Associated productivity losses accounted for an estimated $370 billion in 2015. In India, treatment costs for hypertension alone were projected at nearly $1.2 billion in 2005 prices. With prevalence around 25% in adults, the current costs are far higher.

Expenditures on cardiovascular diseases like heart attacks and strokes which have strong associations with hypertension are likewise enormous. In 2013, India had an estimated 25 million ischemic heart disease and stroke patients. Treatment constituted 1-3% of GDP, imposing a major burden on the healthcare system. Costs are rising rapidly, expected to nearly triple from 2010 to 2030. Heart disease and stroke costs more in lost income and disability than any other disease in India. High out-of-pocket payments for cardiovascular

disease treatment also frequently push households into poverty. One study found over a quarter of affected families had catastrophic health expenditures exceeding 10% of total income. Rural households face even greater burdens due to limited public services.

Premature mortality further contributes to reduced workforce participation and lost economic contribution. Over one-quarter of deaths in India occur from cardiovascular causes, many during working years. The estimated income loss from coronary heart disease mortality alone was $5.7 billion in India as of 2016. High salt intake likely accounts for substantial yet preventable shares of these costs. WHO estimates 1.7 million annual cardiovascular deaths in India are attributable to blood pressure above 115 mmHg. This includes nearly a million premature deaths of adults under age 70. Dietary risks like excess sodium are key modifiable drivers of blood pressure. A 10% reduction in population salt intake could potentially avert hundreds of thousands of CVD deaths per year.

Likewise, WHO projects behavioral risk factors including poor diet account for nearly 60% of lost healthy life years in India. Universal salt reduction is identified as a top priority intervention for lowering CVD burden based on cost-effectiveness. It is considered one of the "best buys" with immense return on investment - each dollar spent generating>$30 in health gains according to some estimates. Realizing these benefits requires urgent action. One analysis forecast over $2 trillion in economic losses for India from 2012-2030 due to heart disease, stroke, and diabetes linked to high salt intake. Implementing salt reduction policies could potentially yield billions annually in healthcare savings and productivity gains while extending healthy life expectancy. The economic case powerfully complements the health rationales for measures to lower sodium across the food system and population diet. Significant public health improvement and progress on non-communicable disease targets hinges on decisive steps to enable low-salt food environments and choices.

2. CURRENT SALT INTAKE LEVELS IN INDIA

2.2 Systematic Reviews Showing Average Daily Intake Around 11g

Multiple systematic reviews and meta-analyses of studies assessing sodium intake in India have found mean consumption ranging from 9 to 12 grams per day at the population level. These concerning figures greatly exceed the WHO recommended maximum of under 6 grams per day and place India among countries with the highest intakes worldwide.

One extensive meta-analysis published in 2017 pooled data from 35 studies conducted between 1981 and 2016, collectively covering over 50,000 Indian participants. It determined the overall mean salt intake was 11.18 grams per day. This far surpassed the recommended 5 gram limit set by the National Institute of Nutrition in India. There was no statistically significant change in intake levels over the 35-year period, indicating persistently high consumption.

The primary dietary sources of sodium were added salt during cooking or as table salt, accounting for an average of 76% of total intake. Processed foods were the second largest source, contributing 16%. High salt levels were prevalent across urban and rural populations, age groups, and genders. However, men on average had higher consumption than women.

Regional data shows equally excessive sodium intakes. A 2014 systematic review of studies in South India found mean intake ranging from 9.45 to 12.5 grams per day. Another meta-analysis of North Indian surveys reported an average of 9.56 grams. Again, added salt was the main source, providing 65-85% of sodium.

Smaller scale reviews have also documented concerning salt consumption patterns. One examining studies in Eastern India calculated typical intake of 10.8 grams daily. Another focusing on urban slum populations estimated mean intakes around 10 grams per day. High blood pressure prevalence ranged from 20-33% in these vulnerable groups, reflecting harms of excessive sodium.

The consistently high estimates across systematic reviews emphasize the urgent need for interventions. They also underscore the reliability and generalizability of the findings, given the meta-analyses synthesized data from multiple robust studies using methods like 24-hour urine collection and dietary recalls. The volumes of evidence leave no doubt that sodium intake in India is dangerously above optimal levels.

Some heterogeneity exists between states and urban versus rural areas, with lower-income groups tending to add more salt at home. However, intake remains substantially elevated across all segments. For instance, one analysis of rural Andhra Pradesh still found mean consumption of 8.7 grams, 36% above the WHO limit. Systematic reviews have not identified any region with average adult intakes close to the recommended target below 6 grams.

The published scientific literature provides ample warning that excessive dietary sodium is the norm across India. While the preferred limit for sodium is under 2 grams per day, even halving current levels would bring immense health gains. The optimal daily intake is equivalent to just one teaspoon of salt. The average Indian is consuming nearly two teaspoons more than this maximum. Drastic reductions are achievable through concerted public health efforts, as demonstrated in other countries. But the troubling status quo indicates the vast scope of work needed to move population-level intake into a healthy range.

2.3 Regional Variations (E.g. Andhra Pradesh Vs Delhi)

While India as a whole has extremely high sodium consumption, intake levels do vary between different states and regions. Some key regional distinctions in salt intake have been reported by studies, including differences between southern states like Andhra Pradesh compared to northern areas including Delhi. However, sodium consumption remains well above recommended limits even in lower-intake regions. Andhra Pradesh in south India has been found to have relatively lower mean intakes compared to other parts of the country. A systematic review of studies in this state calculated average consumption of 8.72 grams of salt per day. This equates to around 3.4 grams of sodium, still nearly double the WHO's optimal level. Nonetheless, the estimated per capita intake in Andhra Pradesh is approximately 20% below the national average.

Surveys in Andhra Pradesh show higher sodium consumption in urban areas at 9.45 grams daily versus 8.02 grams in rural parts. Processed foods make a greater contribution in cities while added salt is responsible for 80% of intake in villages. Regional cuisine features relatively less salt compared to northern diets. Higher intake of rice over wheat products may also contribute to slightly moderate sodium levels. However, excessive discretionary salt use during cooking remains the norm. In comparison, studies in Delhi and surrounding northern regions consistently report higher mean sodium intakes. One systematic review of surveys in Delhi, Haryana and Rajasthan found average consumption of 9.56 grams of salt per day. Other studies observed mean intakes of 9.9 to 11 grams in Delhi slums and urban populations.

Patterns of food consumption in North India likely drive greater salt use. Diets centered on wheat-based breads, savory snacks, pickles and chutneys tend to be saltier. Frequent consumption of dairy products like paneer and lassi also boosts sodium levels. Preparation methods involve more salt-rich spices, oils and

condiments relative to southern cuisine. Again, added salt during cooking accounts for the majority of intake rather than inherent sodium in ingredients. While these regional variations are notable, mean intakes across India remain concerningly high. Even Andhra Pradesh with among the lowest observed levels still averaged 36% above the WHO limit. No major differences are seen in sodium consumption between rural and urban populations once processed foods are accounted for.

Moreover, the range of average intakes does not span from a "low" to "high" level of sodium consumption. Rather, it represents a spectrum from "very high" to "extremely high" compared to the globally recommended guideline. The highest regional intakes are around 1.5 times the lowest, but still 3 times above optimal. This indicates the need for substantial sodium reduction across all parts of India, irrespective of current relative standings. While focusing initial efforts on the highest-intake regions may be pragmatic, no area can be considered to have safe or prudent sodium consumption levels at present. Concerted nationwide initiatives to lower salt in the food system and diets will be essential to move intake into a healthy range of under 2 grams per day. Regional tailoring of strategies may help enhance cultural appropriateness and effectiveness. But the magnitude of reduction required makes this a national priority from Andhra Pradesh to Delhi and beyond.

3. RECOMMENDED SALT INTAKE

3.1 WHO Guidelines of Less Than 6g Per Day for Adults

The World Health Organization (WHO) strongly recommends limiting sodium intake to less than 2 grams per day, equivalent to around 5 grams of salt. This guideline is based on extensive evidence linking high salt consumption to elevated blood pressure, cardiovascular disease, stomach cancer and other adverse health outcomes. While the optimal level is under 2 grams of sodium, the WHO has set a target of under 5 grams of salt (around 2000 mg of sodium) per day for countries to aim for in public health improvements. Specifically, the WHO Guideline on Sodium Intake for Adults and Children states adults should consume less than 5 grams of salt per day. This guideline was issued in 2012 after comprehensive review of decades of population studies demonstrating dose-dependent relationships between sodium and blood pressure. It reaffirmed a similar WHO recommendation in 2003. Authoritative bodies including the American Heart Association and UK National Institute for Health and Care Excellence endorse this limit.

The WHO arrived at this level because high-quality evidence indicates average salt intakes over 5 grams per day are associated with substantially elevated risks of hypertension, cardiovascular events and mortality. Each additional 2 grams of sodium per day is projected to raise systolic blood pressure by around 3 mmHg on average. Reducing intake from a high baseline of 9-12 grams down to 5 grams could thereby prevent millions of heart attacks and strokes annually. Feasibility assessments suggested most populations worldwide should be capable of achieving this target. Importantly, the WHO emphasis that less than 5 grams per day represents an interim goal for countries with very high sodium consumption rather than an optimal long-term objective. Intakes under 2 grams per day result in greatest risk reduction, hence this is considered the ideal target intake. However, the WHO concluded even getting population means down to 5 grams would produce considerable health gains and serve as a realistic milestone for many countries. Reaching this intermediate benchmark will require comprehensive public health strategies.

To reduce average intakes in India to under 5 grams of salt per day, substantial food system changes and shifts in dietary patterns are imperative. This will necessitate both product reformulation to reduce sodium levels across the food supply as well as public education to influence behavior change. Supportive policies

should make lower-sodium foods much more accessible and affordable compared to high-salt options. Clear labeling and restrictions on marketing can also enable consumers to easily identify excessive sodium content.

Considering India's mean intake is currently around double the WHO's intermediary 5 gram limit, major interventions at scale will be essential. Gradual step-wise sodium reduction targets and timelines for different food categories should be implemented to create a pathway for companies and consumers to feasibly reach recommended levels. Continued advocacy, monitoring and accountability mechanisms will be needed to drive steady progress. Achieving adequate population-level reductions requires engagement from all stakeholders - government, industry, communities and individuals. The WHO target serves as an appropriate common goal for collaborative efforts to improve public health through lower salt intake. Combined initiatives addressing multiple aspects of sodium in the food system and diet have potential to reduce average consumption to within recommended limits and substantially reduce the burden of hypertension and non-communicable diseases in India.

3.2 Implications for Babies and Children

The WHO and other authorities emphasize that babies and young children require even lower salt intake than adults to avoid detrimental health impacts. This highlights the critical need to establish low-sodium dietary patterns from complementary feeding onwards to promote lifelong healthy eating. However, evidence suggests many Indian infants and children regularly consume excessive amounts of salt, indicating an urgent need for action. Specifically, the WHO recommends salt intake under 2 grams per day (around 0.8 grams of sodium) for children under 2 years old. For 2-15 year olds, daily sodium should be limited to 2-4 grams depending on age - at most around 1.5 grams of salt per day. These guidelines reflect lower energy requirements and heightened sensitivity to the effects of sodium in early life due to immature kidney function.

In utero sodium exposure may also program developmental changes that predispose to hypertension. Animal studies show high maternal salt intake causes elevated blood pressure, changes in renal function and vascular responses in offspring. Human data links higher maternal sodium consumption with increased newborn BP as well as altered BP reactivity and salt preferences later in childhood. Beyond impacts on blood pressure, excessive sodium has also been associated with reduced bone health in children. High salt diets promote calciuria, which could impair bone mass accrual. One study found teenage girls with sodium excretion above the median had nearly 4% lower bone density on average compared to peers with lower intakes.

However, surveys indicate over 75% of babies over 6 months old in Indian urban areas regularly consume added salt. Average sodium intake for children under 3 is estimated at over 1000mg daily - double the optimal amount. Infant food products also frequently contain excessive sodium. One study found over half of packaged Indian foods for babies had high salt content exceeding the best practice level. Such regular high exposure impairs development of taste preferences and heightens sodium appetite. Children who consume more salt have reduced sensitivity to identifying sodium in foods. They consequently develop a strong liking for intensely salty flavors. Breaking these patterns early is essential for long-term intake in line with recommendations.

Lowering sodium across complementary foods, school meals and family diets is key along with avoiding use of salt in home-prepared baby foods. Products marketed for infants and young children should adhere

to stringent low-sodium standards. Caregiver education and community-based initiatives have potential to reduce discretionary salt use at home. Regulation, reformulation and consumer messaging can make lower-sodium products the default choice. Achieving optimal salt intakes under 1 gram per day for infants and younger children will require extensive changes. But given the short and long-term health consequences, this target is imperative. Establishing low sodium as the dietary norm early in life will pay dividends for cardiovascular and bone health across the lifespan. A coordinated approach across public health, healthcare, industry and families is warranted to ensure Indian children can reap these benefits.

4. HEALTH CONSEQUENCES OF HIGH SALT INTAKE

4.1 Increased Risk of Hypertension, Heart Disease, Stroke

Excessive sodium intake is an established risk factor for elevated blood pressure and strongly linked to increased risks of cardiovascular diseases including heart attacks, heart failure, and stroke. A robust body of epidemiologic evidence demonstrates a dose-dependent relationship between salt consumption and hypertension. Randomized trials also confirm that lowering sodium decreases blood pressure. Through effects on blood pressure as well as direct vascular changes, high salt intake contributes substantially to the development of fatal and non-fatal cardiovascular events.

Large-scale population cohort studies consistently show direct correlations between sodium intake and hypertension prevalence. The INTERSALT study analyzed over 10,000 participants across 32 countries and found a significant positive association between sodium excretion and systolic and diastolic blood pressure. Higher sodium was linked to greater age-related increases in blood pressure. Subsequent studies like INTERMAP confirmed this relationship after adjusting for confounders.

Meta-analyses of randomized controlled trials also demonstrate reductions in salt intake lower blood pressure in hypertensive and normotensive individuals. Dose-response modeling indicates each 2 gram per day decrease in sodium lowers systolic BP by a mean of 4 mmHg in those with hypertension and 2 mmHg in normotensives. Effects are greater in older adults who experience heightened salt-sensitivity. Sustained implementation of reduced salt diets effectively prevents age-related BP rise.

Through these impacts on blood pressure, high sodium intake contributes to atherosclerotic vascular damage over time. Hypertension is a proven causal factor accelerating development of endothelial dysfunction, arterial stiffness, and progressive fibrosis, dilation and wall thickening of vessels. These changes promote plaque formation and instability, clotting, and ischemia. Reducing dietary sodium lowers cardiovascular risk by mitigating hypertension-induced arterial remodeling and dysfunction.

Additionally, high salt appears to worsen cardiovascular risk through mechanisms beyond blood pressure elevation. Evidence links high sodium to fibrosis of the heart, kidneys and vessels, as well as cardiac remodeling. These changes are independent predictors of adverse CV outcomes. Animal studies also show high salt directly damages the endothelium and enhances atherosclerosis via oxidative stress and inflammation.

Consequently, excessive sodium intake causes substantial cardiovascular morbidity and mortality. A meta-analysis found higher salt consumption was significantly associated with greater incidence of stroke and total CVD. Each 5 gram per day increase was linked to 23% and 17% higher risk respectively. Likewise, cohort studies indicate approx. 20% higher CVD mortality for those above versus below median national sodium intakes. Dietary sodium reduction is projected to prevent hundreds of thousands of CVD deaths annually in India alone.

In summary, strong evidence from trials, cohort studies, and mechanistic data underscores excessive salt intake as major contributor to hypertension, cardiac dysfunction, atherosclerosis progression, heart attacks, and strokes. Even modest downwards shifts in population sodium consumption could massively reduce cardiovascular burden. Along with therapeutic lifestyle changes for individuals, population-level strategies to reduce CVD risk warrant prioritizing salt reduction through comprehensive public health approaches.

4.2 Calcium Losses and Impact on Bone Health

High sodium diets have been shown to adversely affect calcium retention and bone health through increased urinary calcium excretion. However, the effect size at a population level remains uncertain, with mixed evidence on tangible impacts on bone mineral density and fracture risks over the long term. Nonetheless, high salt intake may be a risk factor undermining optimal bone accrual and maintenance, particularly in susceptible groups. Reducing sodium consumption likely confers some protective effects on skeletal integrity. Mechanistic and metabolic studies demonstrate increased salt intake causes greater calcium loss through the kidneys. This leads to a net negative calcium balance in the body as urinary excretion exceeds absorption from the GI tract. The sodium-calcium exchange in the kidneys results in calcium mobilization from bone to help restore plasma sodium levels following high salt loads.

Short-term trials in humans have shown substantial increases in urinary calcium within days of increased dietary salt. One found young women had 73% higher calcium excretion on high versus low sodium intake. The magnitude of calciuria is greater in salt-sensitive individuals. Older adults tend to experience amplified calcium excretory responses due to age-related reductions in renal calcium reabsorption capacity. However, longer-term studies on tangible impacts on bone health have had mixed results. Some cohort studies linked higher salt intake to greater bone resorption markers and reduced BMD. But others found no significant correlations, potentially due to adaptive responses over time like enhanced calcium absorption efficiency. Meta-analyses conclude evidence overall remains inconclusive on effects on fracture risk, with a need for larger prospective studies.

Nonetheless, substantial calcium loss from high sodium is still likely detrimental for bone accretion and maintenance, especially in vulnerable subgroups. Along with age-related decreases in renal function, postmenopausal women and young girls experiencing rapid bone growth appear most susceptible to the calcium depleting effects of salt. Secondary hyperparathyroidism from chronic high sodium intakes may accelerate bone loss. Reducing salt consumption can help optimize peak bone mass accrual in adolescence and minimize postmenopausal resorption. Lower sodium may also improve calcium retention on low-calcium diets. Alongside adequate calcium and vitamin D intake, restricting sodium is beneficial for bone health throughout life. Even if population-level impacts are moderate, individual susceptibility factors merit limiting salt intake to recommended low levels.

While the effect size remains uncertain, high sodium does induce potentially detrimental calcium wasting. Further research should clarify at-risk groups and tangibly quantify bone impacts over long periods. In the interim, salt reduction strategies are justified given potential benefits for skeletal integrity amidst proven effects on blood pressure and cardiovascular health. Along with sufficient calcium, vitamins D and K, and exercise, low dietary sodium will help ensure optimal bone health and strength.

5. PROJECTED ECONOMIC IMPACT

5.1 Research Projection of $2 Trillion Loss 2012-2030

A major WHO-backed study in 2009 modeled the immense economic impacts expected in India from 2012-2030 due to cardiovascular disease, cancer and diabetes attributable to high salt consumption. It projected cumulative losses to India of $2.5 trillion over this period, highlighting the urgent need for prevention strategies. This staggering figure underscores the hidden costs of excessive dietary sodium intake. Specifically, the analysis estimated the economic toll of high blood pressure, heart disease, stroke, and stomach cancer linked to high salt intake. Direct costs included hospitalization, medications, healthcare professional visits, and medical procedures. Indirect costs encompassed lost productivity from mortality and morbidity.

Researchers calculated disease burdens attributable to daily salt consumption above the recommended 5g based on meta-analyses of international epidemiological data. Nationally representative surveys provided baseline intake estimates around 12g per day for India. Population, healthcare expenditure, workforce participation and GDP forecasts were integrated to project economic losses. Findings showed CVD and cancer from high salt intake could cost India $2.5 trillion over 18 years, with over half comprising indirect costs. This equates to nearly 1.5% of the country's cumulative GDP from 2012-2030. It underscores the immense healthcare utilization and lost productivity from potentially preventable sodium-related illnesses.

Of total losses, heart disease was responsible for 42% of costs, stroke 32%, and stomach cancer 26%. Nearly 80% of economic impacts resulted from excessive salt consumption above 5g per day rather than inherent sodium levels in a 5g diet. This indicates substantial gains achievable through achievable population-wide salt reduction. Even decreasing mean intake by 3g could avert 5.8 million cardiovascular events over a decade. More recent studies estimate India already loses 1-1.5% of GDP annually to hypertension and CVD attributed to poor diets. One projected cumulative economic losses from heart diseases, stroke and diabetes of $6 trillion from 2011-2030 based on healthcare spending plus income losses from mortality. Again, sodium reduction was identified as a leading cost-effective strategy.

Such projections may even under-estimate true costs given data limitations on morbidity impacts. But they consistently demonstrate excess salt intake imposes a rising economic burden that will become unmanageable without urgent public health action. The WHO has categorized salt reduction as a "best buy" given the exceptionally high benefit-cost ratio. The economic case powerfully complements the health rationales for prioritizing initiatives to lower population-level sodium intake.

5.2 Costs Related to Healthcare, Lost Productivity Etc

The immense economic toll of excessive dietary sodium encompasses both substantial direct healthcare costs as well as indirect costs of lost productivity from morbidity and premature mortality. Analyses of the specific drivers of these costs consistently identify reducing salt intake as a highly cost-effective strategy that can generate major healthcare savings and productivity gains. This further underscores the need for systemic approaches to enable lower-sodium diets. On healthcare costs, the effects of high blood pressure and increased cardiovascular disease risk alone from high salt intake impose heavy burdens on health systems. The price of medications and interventions to control hypertension is growing steadily. One Indian study found average annual drug treatment costs per hypertensive patient rose from $38 to $55 from 2012 to 2018.

More alarmingly, hospitalizations and procedures for heart attacks, strokes and related complications account for huge healthcare expenditures. One round of hospitalization for a serious CVD event can exceed a low-income household's entire annual income in India. Admissions for stroke cost an average of $550, around 5 months' earnings for many Indians. Heart failure hospitalizations average around $3,000, equivalent to 25 months' typical wages.

Overall direct medical spending on CVD in India comprised nearly 6% of health expenditures in 2013, totaling almost $10 billion. One analysis projected that cardiovascular disease costs incurred in India in 2016 exceeded $26 billion. Another estimated hypertension alone cost India $1.2 billion in 2005, equivalent to $1.7 billion today. These costs will continue to rise exponentially without interventions. Lost economic productivity from disability and early deaths connected to high salt intake makes up the other major share of costs. Annually, it is estimated that around 3% of India's potential productive years are lost due to CVD mortality under age 70. Income losses just from coronary heart disease deaths were estimated at $5.7 billion in 2016 for India.

For survivors, chronic disease often forces major reductions in or cessation of work. Nearly 60% of cardiac arrest survivors have to stop working or reduce participation. Lifelong disabilities from stroke and other CVD events also reduce labor capacity. Household impoverishment frequently results, with one study finding over 25% of families with a CVD patient hospitalization experienced catastrophic healthcare costs. In essence, direct healthcare costs and indirect lost productivity together impose an escalating economic toll on individuals, households, communities and nations. This underscores the value proposition of public health strategies like sodium reduction for both improving health and avoiding mounting costs. The case for investment is compelling given the potential for considerable healthcare savings and economic gains.

6. STRATEGIES FOR REDUCING SALT INTAKE

6.1 Promoting Fresh, Unprocessed Foods

Promoting increased consumption of fresh and minimally processed foods is a key strategy to reduce sodium intakes, considering around 75% of dietary salt comes from salt added in home cooking or at the table in India. Fresh fruits, vegetables, grains, legumes, nuts, seeds, herbs, spices and low-fat dairy are naturally low in sodium. Emphasizing these foods enables major cuts in discretionary salt use during meal preparation and eating. Multi-level efforts are warranted to make fresh, unprocessed items the default and desirable choices across all populations.

Achieving adequate intake of fresh produce, including at least 5 servings of fruits and vegetables per day, will substantially lower sodium from Indian diets. Locally available affordable options like lemons, guava, bananas, carrots, spinach, beans and tomatoes are good low-sodium choices. Frozen vegetables and fruits retain freshness and remain low in sodium if without sauce or seasoning. Promoting produce intake through financial incentives, schools programs, worksite policies, and public campaigns can improve affordability, accessibility and desirability.

Choosing minimally processed rice, millet and oat varieties over refined wheat flour or packaged noodles and snacks also reduces sodium exposure. Selecting low-sodium, no-added salt varieties of canned vegetables, legumes, tuna and milk further helps. Probiotic curd or paneer prepared without salt offers protein options much lower in sodium than processed meats or cheese. Nuts and seeds make convenient nutritious snacks, provided they are unsalted.

When homemade meals center around these fresh, low-sodium ingredients, total daily sodium intake stays well under 2000mg even without adding salt during cooking. Broader shifts to plant-focused diets with moderate dairy, legumes, whole grains and nuts will enable the radical reductions from current high intakes needed to align with WHO recommendations.

However, fresh produce and minimally processed base ingredients should become more accessible and affordable to facilitate these changes. Regulations and incentives can improve availability and competitiveness of fresh, low-sodium products compared to salty packaged or fast foods. Price interventions show promise, like one Indian study where a 50% vegetable price discount increased purchases over three-fold. Media, schools and community programs are also important to build knowledge, skills and motivation.

Efforts should promote fresher traditional diets over convenience-focused modern eating patterns. Culinary training to retain taste while lowering salt use also helps. When fresh, minimally processed items are the easiest, most economical and preferred choice, sodium reduction follows. This requires multidimensional initiatives targeting cost, proximity, quality, promotion and consumer education surrounding fresh foods. With enabling environments, meeting sodium targets through increased intake of fruits, vegetables and unprocessed grains, legumes and dairy is eminently achievable.

6.2 Expanding Low-sodium Food Options

Increasing the availability, affordability, and acceptability of lower-sodium packaged foods and restaurant meals is another integral component of strategies to reduce population salt intake. This requires food industry initiatives as well as public policies and consumer education encouraging product reformulation, appropriate labeling and responsible marketing. With more appealing and accessible low-sodium choices across all food environments, average dietary sodium can substantially decrease. A major priority is reformulating high-salt foods to contain less sodium. Categories like bread, cereal, cheese, savory snacks, dressings, curry pastes, and fast food contain very high sodium levels currently. Even modest reductions of 10-25% through gradual reformulation can meaningfully decrease population intake without drastic changes in eating patterns. Structured programs like the UK Salt Reduction Targets have successfully driven industry progress through agreed stepwise reduction goals.

New product development and innovation to introduce reduced or low-sodium variants also expands options. High-sodium bestsellers like chips, sauces and ready meals should have lower-salt line extensions. Expanding healthy options raises awareness and makes switching easy for consumers aiming to reduce intake. Food services have major scope to lower sodium by modifying recipes, sauces, and cooking methods. Training staff on seasoning modifications can reduce added salt by 25% or more without affecting taste. Defaulting to lower-sodium ingredients in combo meals, sandwiches and other popular items can also work. Some chains have successfully introduced low-sodium menus.

Alongside reformulation and innovation, nutrition labeling and marketing tactics should enable informed choices. Warning labels on high-sodium products, color-coded grading schemes, and front-of-pack logos make selection of lower-salt items intuitive. Restricting child-directed marketing of unhealthy high-sodium foods is also important. Promoting reformulated or naturally low-sodium foods should become the new normal. Pricing policies can further spur industry action and steer consumers by making lower-salt items more affordable. Subsidies, rebates or incentives for companies to improve formulations and offer healthier options are helpful. Value meal combinations, discounts or coupons also motivate consumer uptake of

lower-sodium purchases. With supportive government policies, manufacturing capabilities, and demand-focused marketing, reduced-salt foods can become the default. This requires coordinated efforts across public and private spheres to enable transformative industry shifts and empower consumers with knowledge and agency to minimize dietary sodium.

6.3 Use of Alternative Seasonings

Promoting increased use of herbs, spices, vinegars, citrus, garlic, onions and other flavorful plant-based ingredients is an effective way to maintain taste while reducing reliance on salt for seasoning foods. Culinary training programs and campaigns highlighting alternative seasoning options can empower home cooks and food services to progress towards WHO sodium targets without compromising on flavor. The key is utilizing ingredients like herbs, spices, aromatics and acids to add layers, complexity and vibrancy that make dishes appealing even with minimal salt. For example, a marinade of lemon juice, garlic, pepper and cilantro can impart brightness and depth to meats or vegetables that customer palates perceive as flavorful. Chili powder, cumin, mustard seeds, cinnamon and turmeric can give robust texture and taste to legume dishes without salt. Mint, basil, dill and parsley brighten grains and salads.

Blends like garam masala, curry powder and panch phoron as well as pastes like ginger-garlic can provide warming, spicy notes in place of salt. Onion, scallions and chilies lend savory undertones. Vinegar, lime, amchur and tamarind offer sourness to balance out flavors. Whole spices like cumin, coriander, cardamom, fennel and pepper add subtle layers when dry roasted. Oregano, rosemary and thyme provide aromatic complexity as well. Education programs and marketing should highlight these options both for home cooking and restaurants. Chefs skilled in low-sodium cooking can showcase flavor-enhancing techniques like smoking, roasting, marinating and brining to draw out tastes without salt. Ready spice mixes and pastes help make this approach convenient alongside promotion of basic herbs to keep on hand.

Public health authorities can partner with culinary professionals to demonstrate how traditional regional cuisine principles inherently use these alternatives to elevate flavors. Reviving native food wisdom on unlocking taste with few ingredients supports cultural resonance. Hands-on community cooking workshops build skills adaptable across recipes. Consumer campaigns can also showcase examples of cooking flavorful low-sodium meals through short videos or pictorial guides. Simple substitution ideas help transition usage away from salt. Retail promotion and competitive pricing of herbs, spices, garlic, citrus and vinegars boosts home access to flavor boosters. When creatively utilizing the immense range of aromas, tastes and textures naturally present in plant ingredients, sodium can be substantially displaced without any deficiency in taste. In conjunction with other initiatives like product reformulation and labeling, promotion of alternative seasonings provides a pathway to maintain satisfaction and preferences while meeting health targets.

6.4 Education Campaigns

Consumer education is a critical component of a successful salt reduction strategy. Campaigns across mass media, communities, schools and healthcare settings can motivate behavior change by boosting knowledge, shaping attitudes, and providing skills around lowering sodium. Impactful education programs require clear messaging, cultural relevance, repeated exposure and synergies with environmental changes to empower people to make lasting dietary improvements. Mass media channels can efficiently reach broad audiences with sodium reduction messaging at low cost. Campaigns like the UK "Salt - Watch It"

drive communicate consequences of high intake and promote specific behavioral recommendations through platforms like television, radio, print, and online media. Reinforcing simple, actionable tips through repeat public service announcements sustains impact.

Community-based programs enable contextualized education through trusted local leaders and networks. Workshops, competitions, fairs and discussions facilitated by community health workers, women's groups or faith leaders allow tailoring to local culture and cuisine. For example, temple teachings or mosque sermons could emphasize traditional low-salt eating patterns as wholesome and healthy. Schools offer formative venues to instill low-sodium dietary habits through curriculum integration, cafeteria changes and parent engagement. Lessons can make health consequences compelling for children while experiential cooking classes build life-long skills. Parent newsletters and workshops ensure consistent messaging between school and home.

Healthcare settings allow targeted counseling to high-risk groups. Physician guidance on sodium reduction alongside prescription of diuretics for hypertension significantly lowers BP compared to medication alone. Pre-natal and post-natal education helps protect infants and set childhood norms. The common theme across initiatives must be motivating voluntary reduction of discretionary salt and consumption of packaged/restaurant foods high in sodium. Creativity, relatable stories and community partnerships aid effectiveness. Government endorsement and multi-channel coordination with supporting policies strengthens impact.

Sustained, culturally-appropriate consumer education is essential to raise awareness and enable informed choices. However, information alone is insufficient to change entrenched dietary patterns without concurrent efforts to improve food environments. Combining public communication campaigns with interventions to increase affordability and accessibility of fresh, reduced-sodium options offers the best outcomes for long-term dietary change. Well-designed education drives demand while systemic initiatives supply healthier choices. Communication should emphasize actionable steps individuals and families can take like checking labels, modifying recipes and requesting lower-salt restaurant meals to instill self-efficacy. When community members feel empowered with knowledge and skills to control sodium intake amidst readily available low-salt options, dietary patterns transform.

6.5 Policy Approaches (E.g. Sodium Limits for Processed Foods)

Evidence-based policies that create food environments conducive to lower sodium intake are pivotal for meeting public health targets. Regulations directing reformulation, taxation, labeling and marketing are among potential initiatives to drive down population-level consumption. For example, setting gradual upper limits for sodium content across different processed food categories has shown success in many countries. The UK Salt Reduction Strategy established voluntary, progressively lowering sodium targets for around 80 food product categories in phases from 2003-2010. Maximum levels were based on technically achievable thresholds. This stimulated innovation by manufacturers through steps like strategic minereral salts use, altered production processes, and ingredient optimization. By 2011, average sodium in soups fell 45%, cereals 35%, and processed meats 50%. This contributed to 15% lower nationwide salt intake over 7 years.

Following this model, India proposed draft Food Safety and Standards Regulations in 2016 including maximum sodium levels for various food categories to be implemented in phases to 2019. However, political opposition led to an indefinite postponement despite technical feasibility assessments and potential major

public health gains. Continued advocacy is needed to enact mandatory upper limits on sodium content, with a reasonable timeline for industry adaptation. Fiscal policies that make reduced-sodium products relatively lower cost are another effective regulatory lever. Taxes on high-salt foods raise prices to deter consumption, while subsidies for manufacturers to improve formulations or vouchers for consumers choosing low-salt options encourage positive behaviors. Import duties and more stringent nutrient criteria on packaged foods can limit influx of unhealthy products.

Clear front-of-pack labels and warning labels on high-salt packaged foods and menus also enable consumers to easily identify and limit intake of items with excessive sodium. Color coding or standard icons denoting "high, medium or low" salt levels allow quick visual comparisons, backed by public education. Finally, policies should restrict marketing of foods and beverages high in sodium, especially those targeting children. This prevents normalization and demand creation for highly salty, unhealthy items. Oversight mechanisms must also tighten to ensure label claims like "no added salt" are substantiated. In essence, the food environment significantly influences individual choices and intake. Public policies directing industry practices and informing consumers are indispensable to population-level sodium reduction. Government leadership through multi-pronged interventions combining incentives, supply-side reformulation targets, labeling, taxes and awareness campaigns can effectively enable the lower-risk dietary patterns necessary to achieve major health gains.

7. CONCLUSION

7.1 Summary of Main Findings

In summary, current evidence underscores excessive salt consumption as a major public health concern in India requiring urgent action across all sections of society. Average population intake estimated between 9-12 grams per day greatly exceeds the WHO-recommended limit of under 5 grams per day. This places a substantial portion of Indians at considerably heightened risks of hypertension, cardiovascular disease, kidney disease and stomach cancer. Beyond disease burden, high blood pressure attributable to high salt diets also incurs tremendous costs from increased healthcare utilization and lost economic productivity. Multiple large-scale surveys and measurements confirm average adult intake around 11 grams of salt per day across India, regardless of urban or rural location. While some regional variations exist, with slightly lower levels in South India, mean intakes remain universally concerning across all states. Added salt from home or restaurant cooking accounts for 75% of sodium, indicating heavy discretionary use. Processed foods contribute a smaller but growing proportion as intake rises with economic development and market penetration.

Excessive exposure to sodium begins early, with surveys showing 75% of infants over 6 months regularly consuming salt-added complementary foods. This impairs development of preferences for less salty taste. By adolescence, sodium intake already exceeds adult guidelines, predisposing to early elevations in blood pressure. Later in life, age-related declines in kidney function and shifts in thirst sensitivity increase susceptibility to effects of high sodium on hypertension risk. Strong evidence links excessive salt intake to substantially increased incidence and worsened severity of hypertension at the population level. Randomized trials confirm lowering sodium reduces blood pressure in hypertensive and normotensive persons. Effects operate through direct vasoconstrictive actions of sodium as well as longer-term stiffening and remodeling of blood vessels induced by hypertension. In turn, elevated blood pressure strongly amplifies risks of cardiovascular diseases, especially heart attacks and strokes. India faces immense and rising burdens of ischemic heart disease, heart failure and cerebrovascular disease, with high dietary

sodium a major modifiable contributor. Beyond impacts mediated through blood pressure, high salt may also have direct pro-oxidative and profibrotic effects accelerating atherosclerosis progression independently.

Excess sodium has also been associated with greater risks of gastric cancer and potential negative effects on calcium retention and bone density, though links remain less conclusively quantified. Nonetheless, the weight of consistent evidence on hypertension and cardiovascular disease outcomes provides more than sufficient grounds for public health action. Even modest downwards shifts in average national sodium intake could substantially reduce cardiovascular burden and mortality. This makes salt reduction one of the most cost-effective policy interventions available. Yet concerted efforts across all sections of society are essential to bring intake into alignment with dietary guidelines. Campaigns promoting fresh, home-cooked meals with alternative seasonings, product reformulation, front-of-pack labeling, and consumer education are among promising initiatives requiring implementation at scale. With strategic policies and collaborative action, India can potentially avoid millions of cardiovascular deaths annually and reap immense social and economic gains by optimizing sodium consumption.

7.2 Recommendations for Improving Population Health Through Dietary Changes

Strategies to reduce sodium intake must take a multi-level socio-ecological approach combining policy interventions, industry initiatives, and community programs to enable and motivate lowered salt consumption. Several promising interventions should be implemented at scale to shift dietary patterns and bring intake closer to WHO's target below 5g per day. Achieving substantial population-wide reductions will require both limiting sodium levels across the broader food system and empowering individuals to choose lower salt options. This necessitates product reformulation as well as impactful consumer education through mass media and community campaigns.

Establishing structured, stepwise sodium reduction targets for major food categories can stimulate industry to gradually optimize formulations over time through manufacturing adjustments and ingredient changes. Periodic target updates keep driving progress. Mandatory upper limits may be warranted considering the enormity of potential health gains. Clear, color-coded labeling also enables consumers to easily identify high-salt foods. Fiscal levers like taxes on high-sodium products and subsidies lowering costs of reformulated items helps further spur industry action and make healthier options most accessible and affordable. Public procurement policies should be leveraged to set nutrition standards ensuring salt levels in national food programs remain in check.

Public education is equally critical to motivate voluntary behavior change towards fresh, home-cooked meals with minimal discretionary salt. Culinary training programs and campaigns should provide skills and knowledge for flavorful cooking with alternative seasonings in place of salt. Community initiatives allow contextualization for local cuisine preferences. Schools are key venues for early education. At the individual level, dietary counseling for those with hypertension must emphasize sodium restriction. But population-wide strategies are imperative for primordial prevention, as early-life taste preferences and salty food habits predispose to lifelong elevated risks. Health promotion surrounding low-salt diets should become integral to national nutrition policy and messaging. Sustained political commitment and institutional coordination is key for implementing evidence-based initiatives at scale. Monitoring systems must track long-term impacts on intake to ensure steady progress. Rigorous evaluation provides insights for optimizing strategy. With concerted efforts across all societal sectors, India can potentially avoid millions of needless deaths and gain billions in economic savings annually through pragmatic salt reduction

policies and programs. The health and economic cases powerfully compel prioritization of this goal in the fight against non-communicable diseases.

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