Hypertension in Vietnam:

prevalence, risk groups and effects of salt substitution

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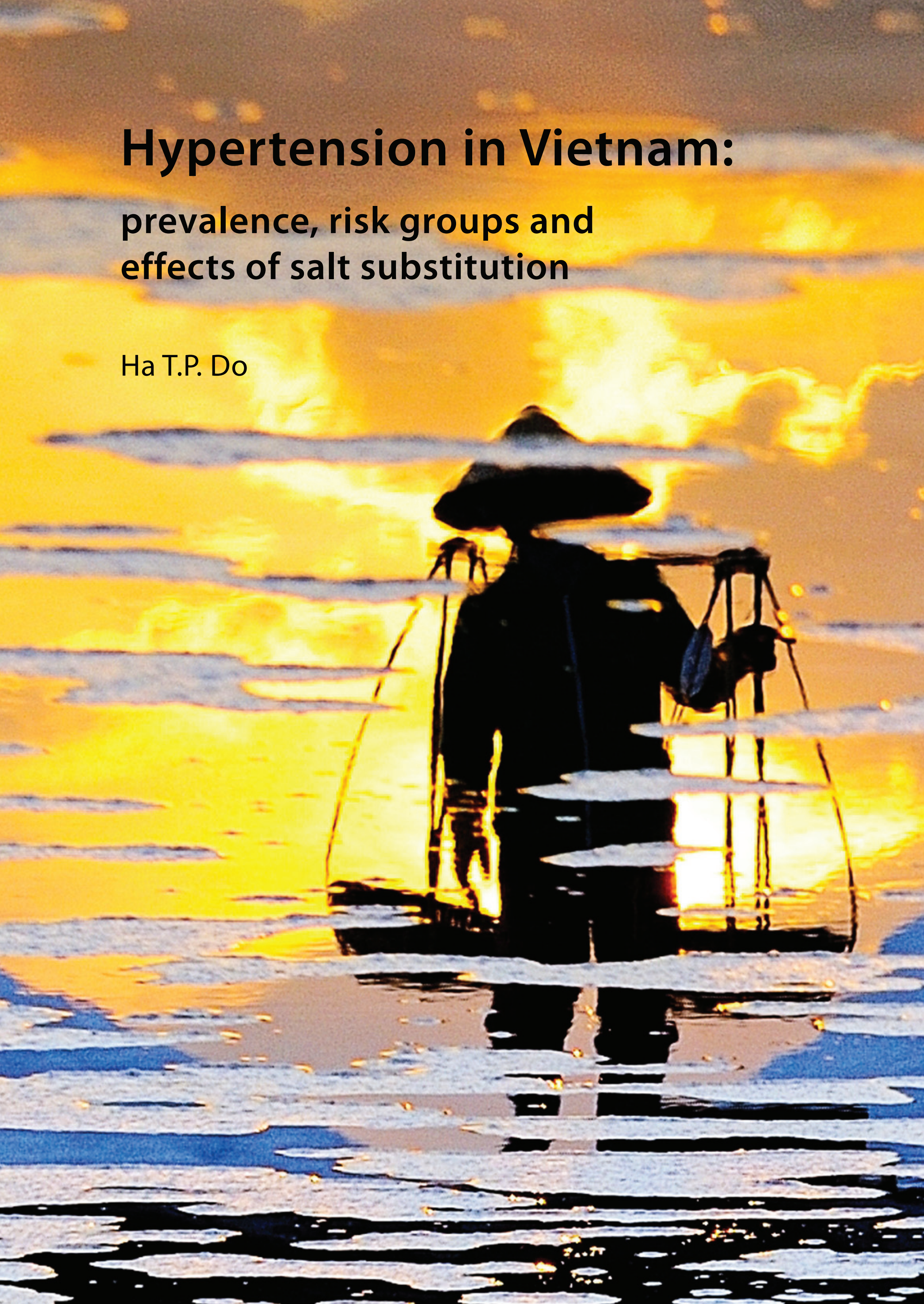

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Ha T.P. Do

(Do Thi Phuong Ha)

Thesis

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ABSTRACT

Background Over the past decades, the morbidity and mortality patterns have changed rapidly in Vietnam, with a reduction in infectious diseases in parallel with a rapid increase in non-communicable diseases (NCDs), leading to the so-called double burden. It was estimated that in 2008 NCDs accounted for 75% of all deaths in Vietnam, and cardiovascular diseases were the leading cause accounting for 40% of total mortality. Hypertension is one of the major risk factors for cardiovascular disease, but information on the nationwide prevalence and main determinants is lacking. There is an urgent need for appropriate population-based interventions for hypertension control and prevention in Vietnam.

Methods and results Data of 17,213 adults aged 25–64 years from the nationally representative 2005 National Adult Obesity Survey were used to study the prevalence of hypertension and prehypertension and their determinants. The overall prevalence of hypertension was 20.7% and the prevalence of prehypertension was 41.8%. Hypertension and prehypertension were more prevalent in men than in women (25.2% vs. 15.9%). Determinants of raised blood pressure including advancing age, overweight, alcohol use (among men), and living in rural areas (among women) were independently associated with a higher prevalence of hypertension, whereas higher levels of physical activity and education were inversely associated. Age, body mass index (BMI), and living in rural areas were independently associated with an increased prevalence of prehypertension. Among the hypertensives, only 25.9% were aware of having hypertension and 12.2% were treated. Among the treated hypertensives, 32.4% had their blood pressure controlled.

Overweight and obesity, important risk factors for hypertension, were investigated using data of 14,452 Vietnamese adults aged 25–64 years from the nationally representative 2000 National Nutrition Survey and data of 17,213 adults aged 25–64 years from the nationally representative 2005 National Adult Obesity Survey. The results showed that the distribution of BMI across the population and in population subgroups indicated a shift towards higher levels in 2005 as compared to 2000. The nationwide prevalences of overweight (BMI ≥25 kg/m^2) and obesity (BMI ≥30 kg/m^2) were 6.6% and 0.4% respectively in 2005, almost twice the rates of 2000 (3.5% and 0.2%). Using the Asian BMI cut-off of 23 kg/m^2 the overweight prevalence was 16.3% in 2005 and 11.7% in 2000. Women were more likely to be both underweight and overweight than men in both 2000 and 2005. Urban residents were more likely to be overweight and less likely to be underweight as compared to rural residents in both years. The shifts from underweight to overweight were more pronounced in those with higher food expenditure levels.

A survey on sodium intake among a rural community near Hanoi (n=121) showed that mean 24-hour sodium excretion was 188.6 ± 57.5 mmol (4.3 g), which corresponds to an intake of salt (sodium chloride) of 10.8 ± 3.3 g/day. Men had a higher mean sodium excretion (196.8 ± 56.9 mmol/day or 4.5 g/day) than women (181.1 ± 57.4 mmol/day or 4.2 g/day); 97.5% of the men and women had a salt intake higher than the World Health Organization's recommendation of <5 g/day. Subjects with complete urine collection had a salt excretion of 11.7 g/day. Sodium in condiments added during cooking or eating at the table accounted for 81% of sodium intake. Processed foods contributed 11.6% and natural foods 7.4%. Regarding the condiments, the largest source was the mixed seasoning ('bot canh', 35.1% of total); 31.6% of total dietary sodium was provided by fish sauce, 7.4% by monosodium glutamate and 6.1% by table salt.

Sodium-reduced and potassium-enriched salt and bot canh, a traditional seasoning, were experimentally produced and underwent organoleptic testing, which showed high acceptance. An 8-week randomized double-blind trial was carried out in 173 men and women between 45 and 64 years of age with untreated (pre)hypertension in a rural Vietnamese community. The intervention group that received sodium-reduced and potassium-enriched condiments (salt and 'bot canh') experienced a median 24-hour sodium excretion decrease of 28.5 mmol/d (1.6 g/d salt) compared to the control group that received regular condiments for home food preparation and dining. The mean change in BP in the intervention compared to the control group was -2.6 mmHg (95% CI -4.6 to -0.5, p=0.013) for systolic BP and -1.6 mmHg (95% CI -3.0 to -0.2, p=0.024) for diastolic BP. The prevalence of iodine deficiency was significantly reduced in both groups (from 66% to 41% in the intervention group and from 72% to 36% in the controls).

Conclusion Hypertension and prehypertension are prevalent in Vietnam, but awareness, treatment, and control are low. Lifestyle modifications, including the prevention of overweight, and the promotion of physical activity, particularly in urban areas, and the reduction of high alcohol consumption in men, may help to prevent hypertension in Vietnam. Between 2000 and 2005, BMI in the population shifted towards higher levels, especially in those with higher food expenditure levels, but under nutrition was also still prevalent in 2005. Most dietary sodium (81%) comes from adding salty condiments during food preparation or at the table. Therefore, limiting condiments added during cooking and at the table should be given priority. Alternatively, regular condiments may be replaced with sodium-reduced and potassium-enriched salt and bot canh to lower BP in (pre)hypertensive Vietnamese adults. Salt iodization should be reconsidered to ensure adequate iodine intake of the population.

Contents

Chapter 1

General introduction

1 INTRODUCTION

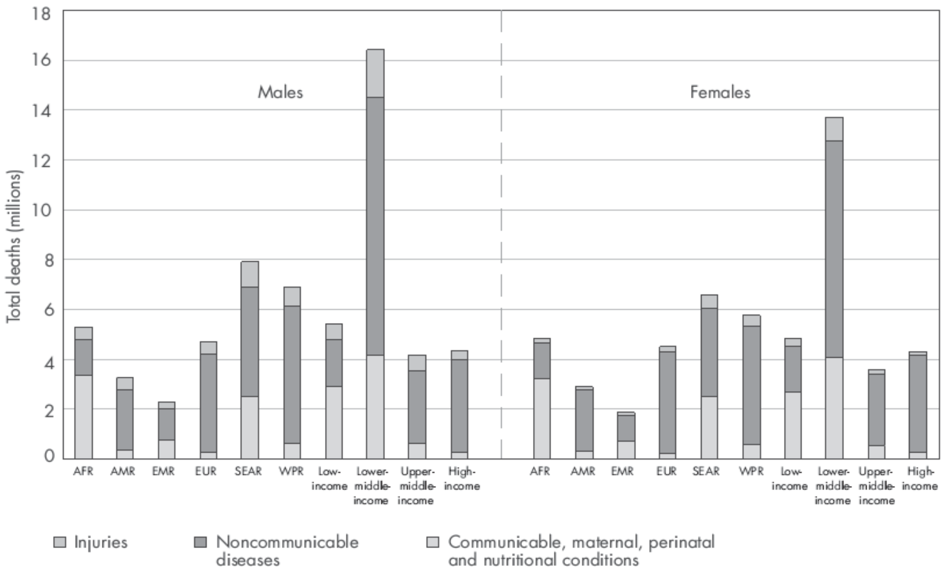
Vietnam, a developing country, is situated in South East Asia, bordering China, Laos, and Cambodia. In 2000, Vietnam's population amounted to 77.6 million, of which 76% lived in rural areas.[1] With an average annually increase of 1.37% Vietnam's population increased to 83.1 million in 2005[2] (73% in rural areas) and 90 million in 2013 (68% in rural areas).[3] Over the last decades Vietnam has seen a large increase in economic growth.[4] As a result, poverty was halved in the period of 1998–2004 and the general poverty rates reduced from 37.4% to 19.5% while the food poverty rate went down from 13.3% to 6.9% in the same period. In parallel with this economic growth urbanization rapidly increased, which is expected to grow by more than 3% per annum (currently 3.06%) until 2020. Typical of East Asian nations it is estimated that the urban area accounts for 70% of growth while covering only 25% of the population.[5]

The morbidity and mortality patterns have changed quickly during the last decades, with a reduction in infectious diseases in parallel with a rapid increase in non-communicable diseases (NCDs), leading to the so-called double burden. It was estimated that in 2008 NCDs accounted for 75% of all deaths in Vietnam.[6] Hence, it is clear that there is an urgent need for better understanding of risk factors and appropriate population-based interventions to control and prevent NCDs in Vietnam.

1.1 NCDs and cardiovascular morbidity and mortality

Globally, a total of 57 million deaths occurred during 2008; 36 million (63%) were due to NCDs, principally cardiovascular diseases (CVD), diabetes, cancer and chronic respiratory diseases.[7] Nearly 80% of these NCDs' deaths (29 million) occurred in low- and middle-income countries (Figure 1.1). NCDs are the most frequent causes of death in most countries in the Americas, the Eastern Mediterranean, Europe, South-East Asia, and the Western Pacific. In low- and middle-income countries NCDs also cause mortality at a younger age (29% of NCD deaths occur among people <60 years, versus 13% in high-income countries).

World Health Organizations' (WHO) projections show that NCDs will be responsible for a significant increase of 15% in the total number of deaths between 2010 and 2020. The greatest increase will be in the WHO regions of Africa, South-East Asia and the Eastern Mediterranean, where the number of deaths will increase by more than 20%. The regions



(Note: AFR=African Region, AMR=Region of the Americas, EMR= Eastern Mediterranean Region, EUR= European Region, SEAR=South-East Asia Region, WPR=Western Pacific Region).

Figure 1.1 Total deaths by broad cause group, by WHO Region, World Bank income group and by sex, 2008.[12]

that are projected to have the greatest total number of NCD deaths in 2020 are South-East Asia (10.4 million deaths) and the Western Pacific (12.3 million deaths).[8] In addition to the longstanding challenges of curtailing infectious disease, this double burden of disease places enormous strains on resource-deficient health systems.

The increased burden of NCDs in low-income and middle-income countries contributes to poverty and is becoming a major barrier to development and achievement of the Millennium Development Goals. NCDs disproportionately affect individuals who are poor, thus increasing inequalities.[9] NCDs are chronic and can lead to continued expenditures that trap poor households in cycles of debt and illness, causing health and economic inequalities. Household costs of NCDs have a substantial macroeconomic effect. The loss of productivity reduces a society's effective labor force, resulting in reductions in overall economic output. For every 10% rise in mortality from NCDs, the yearly economic growth is estimated to be reduced by 0.5%.[10] In 2008, cardiovascular diseases (CVD) were the leading cause of death in Vietnam, accounting for 40% of total mortality.[6] CVD is a lifestyle-related disease. It has been estimated that behavioral risk factors, including tobacco use, physical inactivity, and unhealthy diet, are responsible for about 80% of coronary heart disease and stroke.[11]

1.2 Raised BP

Raised BP changes the structure of the arteries. As a result, the risk of stroke, coronary heart disease, kidney failure increases. Other complications of raised BP include heart failure, peripheral vascular disease, and visual impairment.[13] Globally, the prevalence of raised BP in adults aged 25 and over was around 40% in 2008 according to WHO figures. Because of population growth and ageing, the number of people with hypertension rose from 600 million in 1980 to nearly 1 billion in 2008.[14] The prevalence of raised BP was consistently high in low-, lower-middle- and upper-middle-income countries, all having rates of around 40% for both sexes. The prevalence in high-income countries was somewhat lower, at 35% for both sexes.[12]

The Global Burden of Disease study in 2004, updated in 2008,[8] showed that raised BP was the main cause of mortality worldwide, estimated to cause 7.5 million deaths, about 12.8% of the total of all annual deaths (Figure 1.2 and 1.3). Its contribution to mortality is higher than for tobacco use (9%), high blood glucose (6%), physical inactivity (6%), and overweight and obesity (5%).[15] Raised BP is a major risk factor for CVD, and estimated to be responsible for 62% of stroke and 49% of coronary heart disease.

Reducing BP to clinical target levels below 140/90 mmHg lowers CVD risk and cardiovascular complications.[16] The risk of CVD, however, not only increases above this cut-off level but across the entire range of BP, starting at levels of 115/75 mmHg.[17] Treating only

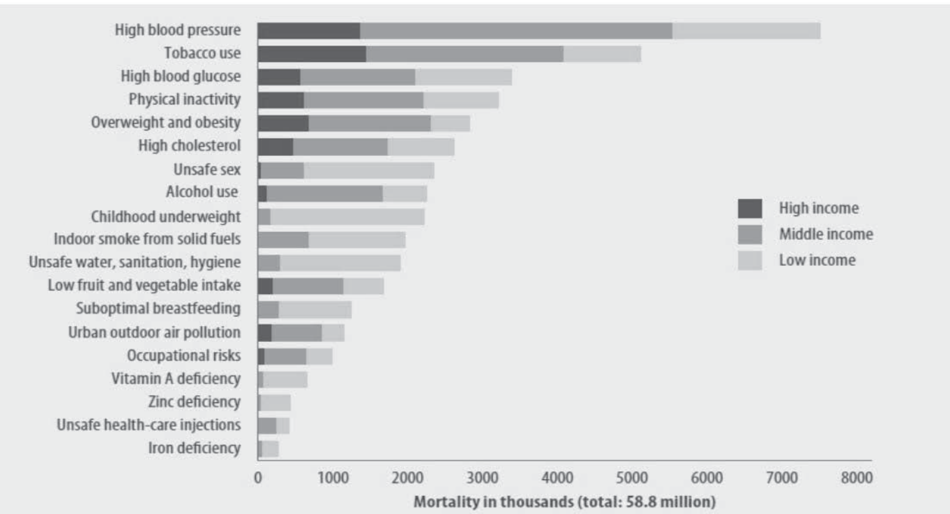


Figure 1.2 Deaths attributed to 19 leading risk factors, by country income level, 2004.[8]

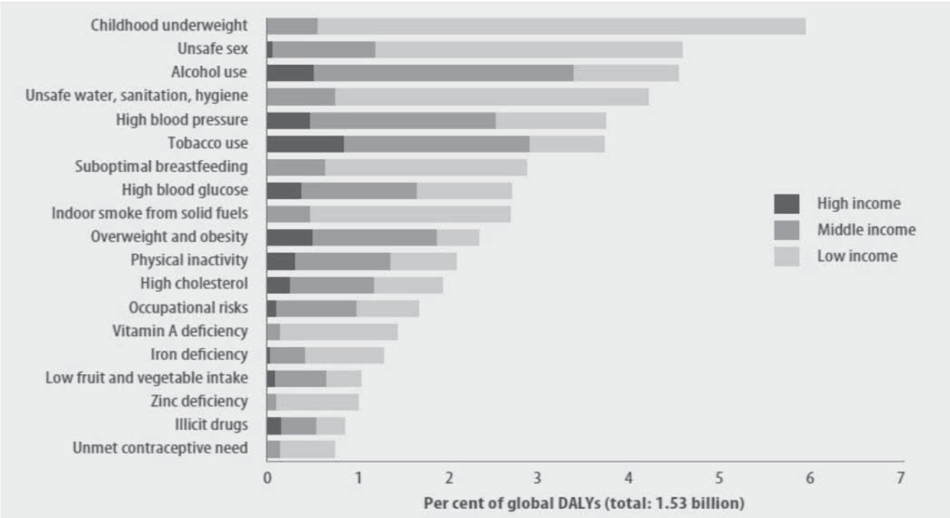


Figure 1.3 Percentage of disability-adjusted life years (DALYs) attributed to 19 leading risk factors, by country income level, 2004.[8]

individuals with clinically diagnosed hypertension will therefore be insufficient to reduce the burden of CVD related morbidity and mortality in the community. Preventive, non-pharmacological strategies to shift the overall population BP distribution to a lower level is therefore warranted (Figure 1.4).

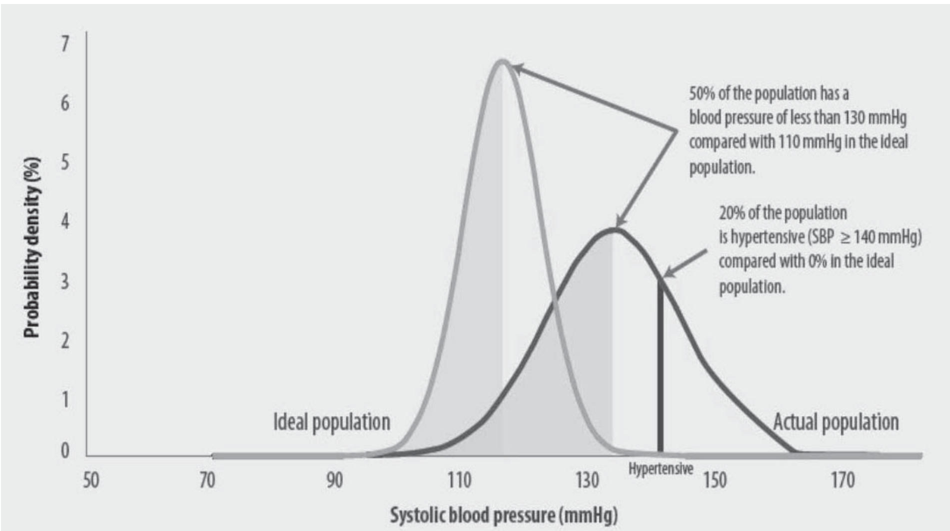


Figure 1.4 An observed population distribution of average systolic BP (right-hand distribution) and the ideal population distribution of average systolic BP (left-hand distribution).[15]

1.3 Raised BP and modifiable lifestyle risk factors

Overweight and obesity

Obese individuals are more likely to have elevated BP,[18-20] and weight loss by means of caloric restriction has been shown to effectively reduce BP in overweight subjects by ~1 mmHg per kilogram.[21]

Overweight and obesity are associated with many physiological and metabolic changes that promote hypertension.[22] Obesity may predispose to hypertension by promoting renal sodium retention through insulin resistance[23] and it increases the risk of chronic kidney disease, which, in turn, may promote sodium retention.[24] Obesity may also be associated with increased plasma leptin levels and resistance to leptin, abnormal plasma levels of coagulation factors, increased reactive oxygen species, inflammation, and endothelial dysfunction, which may also contribute to hypertension.[25-29]

In Asian people, the direct association of overweight and obesity with cardiovascular risk factors, including hypertension, occurs at lower weights-for-height than in Caucasians. The overall and stratified analyses suggested optimal BMI cut-offs of 23–24, 21–22.5, and 20.5–21 kg/m^2 for Chinese, Indonesian, and Vietnamese adults, respectively, are the best cut-offs for determining increased risk of hypertension for those with BMI above these cut-offs in these populations.[30] It was also found that even lower BMI cut-off values (21.2 and 22.1 kg/m^2 for men and 21.2 and 22.9 kg/m^2 for women) than those recommended for an Indo-Asian population yielded the optimal areas under the curve for the associations with hypertension and diabetes, respectively.[31] Therefore a BMI cut-off point of 23 kg/m^2 has been recommended for classification of overweight in Asian populations.[32]

The long-term effects of fetal undernutrition on the propensity for obesity and hypertension has also been reported. Undernourished children were more likely to become overweight in childhood and to have a high prevalence of obesity, hypertension, and diabetes mellitus, among other disorders, when they aged into their fifties and sixties.[33]

1.4 Unhealthy diet

Sodium

It has been shown that a high salt intake, low consumption of fruit and vegetable (i.e. low potassium intake), high energy intake, excess alcohol intake, and high consumption of saturated and trans fatty acids, low consumption of fibre and several other diet components, all contribute to the development of high BP. However, the strength of the evidence may be greater for salt than for other factors.[34] Overconsumption of salt has been estimated to cause up to 30% of all cases of hypertension[35] and dietary salt has been linked to various diseases including stroke,[36] left ventricular hypertrophy,[37] kidney disease, stomach cancer,[38] renal stone formation and osteoporosis,[39,40] and obesity.[34]

Salt can raise BP by several mechanisms. There is much evidence that individuals who develop high BP have an underlying defect in the kidneys' ability to excrete sodium.[34] Impaired ability of the kidneys to excrete sodium causes sodium and water retention, particularly on a high salt intake, leading to volume expansion and the stimulation of various compensatory mechanisms which also eventually cause BP to rise. Plasma sodium is a major determinant of extracellular volume, thereby, influencing BP. At the same time, small changes in plasma sodium may have a direct effect on BP, independent of extracellular volume, by directly affecting the hypothalamus's control of BP through the local renin-angiotensin system.[41] The changes in BP were directly related to the changes of intracellular sodium which affect vascular smooth muscle tension and thereby BP.[42] Recent studies have shown that salt intake also affect endothelial function thus can influence BP.[43] Finally, high salt intake is associated with obesity through soft drink consumption[34] and therefore raise BP via the mechanism which obesity increase BP.[18]

The average salt intake in most countries around the world is approximately 9–12 g/d, with many Asian countries having mean intakes of more than 12 g/d.[16]

Based on the reductions in BP from a meta-analysis of randomized salt reduction trials, it was estimated that a reduction of 6g/d in salt intake would reduce stroke by 24% and coronary heart disease by 18%, which would prevent approximately 2.5 million deaths worldwide.[44]

Randomized trials have demonstrated that a reduction in salt intake causes further decrease in BP in individuals who are already on antihypertensive drug treatments. It also enhances BP control and reduces the need for antihypertensive drug therapy.[45] In addition to its effects on BP, a reduction in salt intake may have beneficial effects on the cardiovascular system independent of BP,[46] such as stroke,[47] left ventricular hypertrophy.[48] Therefore, the total effect of salt reduction on cardiovascular outcomes may be larger than those estimated from BP falls alone.[34]

The suggested global goal by WHO is to reduce salt intake to less than 5 g (2000 mg sodium) per person per day[49] by 2025.[50]

Potassium

Potassium deficiency, even of a mild nature, may induce renal sodium retention, increase BP, and produce salt sensitivity[51-53] Meta-analyses reported that potassium supplementation significantly lowers systolic and diastolic BP.[54,55]

Potassium intake may lower BP by a number of mechanisms such as increase of sodium excretion, modulate baroreflex sensitivity, directly cause vasodilation, or reduce cardiovascular reactivity to norepinephrine or angiotensin II.[56]

It has been recommended that an adequate potassium intake should be maintained to prevent or treat hypertension, particularly in subjects who are unable to reduce their sodium intake and in those who are salt sensitive or who have a family history of hypertension.[56]

Clinical studies concerning potassium intake support the thesis that potassium supplementation (e.g. 60–120 mmol/d) lowers BP.[22] Meta-analyses also reported that potassium significantly lowered systolic and diastolic BP in subjects with essential hypertension.[54,57] Cappuccio and MacGregor showed that the magnitude of the BP lowering effect is greater in patients with high BP (-8.2 mmHg [95% CI, -9.1 to -7.3 mmHg] systolic and -4.5 mmHg [-5.2 to -3.8 mmHg] diastolic) and appears to be more pronounced the longer the duration of the supplementation.[54]

It was reported that together with a reduction in sodium intake to about 70 mmol/day an increase of dietary potassium to 85 mmol/ day could maintain a lower BP and reduce the burden of CVD.[58] A review by Geleijnse et al. of 40 sodium trials and 27 potassium trials in adults with a minimum duration of 2 weeks concluded that reduced intake of sodium (-1.8 g/d) and increased intake of potassium (+1.7 g/d) could make an important contribution to the prevention of hypertension, especially in populations with elevated BP.[57]

Based on these analyses, an increase in potassium intake may be included in the recommendations for a non-pharmacological approach for hypertension prevention, particularly in population with potassium deficiency.[54]

Other dietary factors

Magnesium: The antihypertensive effects of magnesium supplements in hypertensive individuals are controversial. Some studies show that magnesium reduces BP,[59,60] whereas other studies do not.[61] The antihypertensive effects of magnesium supplementation are small in those studies that suggest such an effect. Further studies are required to investigate the effect of magnesium on BP.

Calcium: Several meta-analysis of observational studies showed an inverse relationship between calcium intake and BP, but the size of the estimate was small with evidence of publication bias and heterogeneity across studies.[61] A number of meta-analyses of randomized control trials indicated that calcium supplementation may reduce BP, mainly in hypertensive patients.[62] A large meta-analysis including 42 studies on the effects of supplemental calcium reported a BP reduction of -1.44 mm Hg/ -0.84 mmHg.[63] Heterogeneity in BP response after calcium supplementation may be related to the calcium content of the background diet, with effects being observed in those with deficient diets[64,65] and no effect in those who already have an adequate calcium intake.[62,63,66]

Vitamin D: Several studies suggest that, in addition to bone mineral and divalent ion metabolism, vitamin D may reduce insulin resistance and have vascular, renoprotective, and anti-inflammatory effects.[67,68] Hence, vitamin D may reduce BP and also prevent or ameliorate a number of the vascular and renal complications of hypertension. The antihypertensive effects of vitamin D seem to be particularly prominent in vitamin-D-deficient patients with elevated BP.[67]

Fatty acids: A meta-analysis of 31 placebo-controlled clinical trials indicated that in people who are assigned to a relatively high omega-3 fatty acid intake (~3 g/d), there is a significant reduction in BP in hypertensive individuals, and little or no effect in normotensive persons.[69] There was also a dose-response relationship between fish oil (high) dose and systolic BP and diastolic BP reduction. The hypotensive effect may be strongest in hypertensive subjects and those with clinical atherosclerotic disease or hypercholesterolemia.

Dietary fiber: Dietary fiber is considered part of a healthy diet that may exert protective effects on the cardiovascular system. A meta-analysis of 24 trials showed that increasing dietary fiber intake in Western populations, where the usual fiber intake is well below recommended levels, may help to prevent hypertension.[70] Another meta-analysis reported that increased intake of dietary fiber may reduce BP in hypertensive patients; in normotensive individuals, there was a smaller, less conclusive, reduction in BP.[71]

Health-promoting diets

There has been a growing focus on the use of complex diets to prevent or treat hypertension. The composition of these diets is generally based on pre-existing evidence that the individual constituents of these diets have preventive or therapeutic effects on hypertension. Short-term studies indicate that specialized diets may prevent or ameliorate mild hypertension; most notable are the Dietary Approaches to Stop Hypertension (DASH) diet, which is high in fruits, vegetables, and low-fat dairy products, and the DASH low-sodium diet.[22] However, all the reported trials were of short duration (up to 8 weeks) and thus the long-term compliance to these diets is at present unknown. The Mediterranean diet, which is high in fruits, vegetables, and olive oil, has also been associated with a reduced CVD risk in observational studies.[72]

1.5 Other modifiable BP determinants

Physical activity

Physical inactivity has been identified as the fourth leading risk factor for global mortality (6% of deaths globally).[15] An inverse dose-response association between levels of recreational physical activity and risk of hypertension has been observed in several studies.[73,74] A meta-analysis of prospective cohort studies suggested that both high and moderate levels of recreational physical activity were associated with decreased risk of hypertension, with a pooled relative risk (RR) of 0.81 (95% confidence interval, 0.76–0.85) for high vs. low and RR of 0.89 (0.85–0.94) for moderate vs. low levels of activity.[73] Physical activity is a key determinant of energy expenditure and fundamental to weight control.[75]

Alcohol consumption

Excessive alcohol intake has been shown to increase BP.[76,77] Positive associations of the amount of alcohol consumed with BP and the prevalence of hypertension were found, independent of age, years of education, smoking, and use of oral contraceptive and antihypertensive drugs.[78] The consumption of 30 g/day ethanol was associated with increases of 1.5 and 2.3 mmHg in diastolic and systolic BP, respectively, for men, and 2.1 and 3.2 mmHg, respectively, for women. The prevalence of hypertension was higher among those ingesting more than 30 g/day (odds ratio of 2.9, $p<0.01$). Reduced alcohol intake lowered BP in randomized controlled trials by approximately 1 mmHg per glass per day.[77]

Although alcohol increases BP, there are epidemiological data indicating that a moderate level of alcohol consumption could reduce CVD risk through other mechanisms.[22]

Smoking

Smoking may account for almost 10% of CVD.[79] Impairment of endothelial function, arterial stiffness, inflammation, lipid modification as well as an alteration of antithrombotic and prothrombotic factors are smoking-related major determinants of initiation, and acceleration of the atherothrombotic process, leading to cardiovascular events.[80] Cigarette smoking acutely exerts an hypertensive effect, mainly through the stimulation of the sympathetic nervous system.[80] There is less evidence for a chronic effect of smoking on BP. Hypertension was associated with number of years of smoking and lifetime cigarette consumption, but was not associated with current smoking status in a Vietnamese population.[81]

2 SALT REDUCTION STRATEGIES

WHO and NCD Alliance identified salt reduction together with tobacco control, and treatment of people at high risk of CVD as three priority cost-effective interventions to control NCDs.[50] An estimation of the effects and cost strategies to reduce salt intake and control tobacco use was done for 23 low-and middle-income countries that account for 80% of chronic disease burden in the developing world.[82] It demonstrated that a reduction in salt intake is more, or at the very least just as, cost-effective as tobacco control in reducing CVD on its own. In a 10-year-period (2006–2015), a 15% reduction in mean population salt intake could avert 8.5 million CVD deaths and a reduction in smoking prevalence could save 3.1 million deaths. Salt reduction programs would include a voluntary reduction in the salt content of processed foods and condiments by manufacturers plus mass sustained media campaign aimed to encourage dietary change within households and communities. The cost of salt reduction was estimated to be USD 0.09 per person per year, whereas the cost for tobacco control including both price and non-price measures was USD 0.26 per person per year.[82]

2.1 Salt intake and dietary sodium sources

Sodium intakes around the world are well in excess of physiological needs, which is 10–20 mmol/day.[16] Most adult populations have mean sodium intakes >100 mmol/day, and for many (particularly Asian populations) mean intakes are >200 mmol/day. Excessive sodium intake already occurs in childhood.[83] In European and Northern American countries, sodium intake is dominated by sodium added in manufactured foods (approximately 75% of intake). In many Asian countries such as in Japan (63%) and China (76%), salt added at home (in cooking and at the table) and soy sauce were the largest sources.[84] If policies for salt reduction at the population level are to be effective, policy development and implementation needs to target the main source of dietary sodium in the various populations.[16]

2.2 Health education and dietary counselling on salt reduction

Health education has effects on salt reduction. A successful intervention study was conducted in Portugal that achieved a difference of approximately 50% in salt intake between 2 villages by means of health education on salt reduction. After 2 years of intervention, there was a difference of 13/6 mmHg in BP.[85] A randomized community based intervention study in 2 rural villages in Japan demonstrated that dietary counselling for 1 year reduced salt intake by 2.3 g/d and systolic BP by 3.1 mm Hg.[86]

The Hypertension Prevention Trial was a multicentre randomized trial designed to assess the effects of long-term dietary changes on BP in a normotensive population for 3 years. The dietary counselling treatments were reduction of sodium intake, increase of potassium intake, and decrease of energy intake. At the end of the intervention, the treatment groups had sodium intakes that were 30% to 40% lower than those of the controls.[87]

The Trials of Hypertension Prevention (TOPH 1) study was a 18 month-randomized controlled multicentre trial testing the efficacy and effectiveness of seven non-pharmacological interventions on BP.[88] Among three life-style change groups (weight reduction, sodium reduction, and stress management), the sodium reduction group significantly lowered 24-hour urinary sodium excretion by 44 mmol and BP by 1.7/0.9 mmHg.[88] A post-trial follow-up seven years later indicated that the dietary sodium restriction group had a 35% lower hypertension risk.[88]

The TOPH 2 tested interventions to promote weight loss, dietary sodium reduction, and their combination for lowering diastolic BP, systolic BP, and the incidence of hypertension during a 3- to 4-year period in overweight participants with high-normal BP.[89] Urinary sodium excretion was significantly reduced in both interventions with sodium reduction compared to control groups at 6 and 36 months. Compared with the control group, BP decreased 3.7/2.7 mm Hg in the weight loss group, 2.9/1.6 mm Hg in the sodium reduction group, and 4.0/2.8 mm Hg in the combined group at 6 months (all groups, $p<0.001$), with smaller reductions after 36 months. Although the BP effects declined over time, the average risk reductions in hypertension incidence were still present after 48 months (relative risks of 0.78–0.82).

The DASH-Sodium Trial was a multi-centre study in which 412 adults with untreated systolic blood pressure of 120 to 160 mm Hg and diastolic blood pressure of 80 to 95 mm Hg randomized to the intervention group received a DASH combined diet (fruit and vegetable-rich and low fat dairy products and with reduced saturated and total fatty acid content diet) or the Western diet (control) for 30 days each with three different dietary sodium levels, i.e. a high-sodium diet that provided 150 mmol/d — roughly a typical American sodium intake; an intermediate-sodium diet with 100 mmol/d — a currently recommended maximum intake; and a low sodium intake with 50 mmol/d in a cross-over design.[90] In all subgroups, the DASH diet and reduced sodium intake were each associated with significant decreases in BP; these two factors combined produced the greatest reductions with dose-response manner. Among nonhypertensive participants who received the control diet, lower (vs. higher) sodium intake decreased blood pressure by 7.0/3.8 mm Hg in those older than 45 years of age ($p<0.001$) and by 3.7/1.5 mm Hg in those 45 years of age or younger ($p<0.05$). These BP reductions with the DASH low- sodium diets were in addition to the BP- lowering effects of the DASH diet itself. At each level of sodium intake, the systolic BPs and diastolic BPs were usually substantially lower with the DASH diet as compared to the control Western diet.

2.3 Processed food reformulation of sodium content

As the consumption of processed foods rises in many countries, a change in the industry norms to reduce the addition of salt now will have important benefits in the future, together with government regulation.[91] Mandatory and voluntary reductions in the salt content of processed food are cost-saving interventions under all modelled scenarios of discounting, costing and cardiovascular disease risk reversal (dominant cost-effectiveness ratios).[91] Programmes to encourage the food industry to reduce salt in processed foods are highly recommended for improving population health and reducing health sector spending in the long term, but regulatory action from government may be needed to achieve the potential of significant improvements in population health.

2.4 Salt substitution

Salt substitution is an approach that may contribute to the salt reduction in population with high proportion of dietary salt intake coming from salt or salty seasoning added to food during food preparation or at the table like many Asian populations. Reducing sodium, and also increasing potassium, while maintaining long lasting salty taste is an advantage of salt substitution.

The effects of a 1:1 mixture of sodium and potassium chloride on sodium intake and BP was studied by Mickelsen et al.[92] The results showed that sodium intake associated with seasoning at the table was reduced with the 1:1 mixture to 44% of the amount consumed with regular table salt, and over a 28-day period there was no tendency for subjects to increase their use of a 1:1 mixture when used in place of regular table salt, to compensate for their reduced sodium intakes. However, there was only a slight change in mean BP of -1 mmHg/-1 mmHg in the mixture group vs. +1 mmHg/+3 mmHg in the controls.[92]

In the Netherlands, a 6-month randomized controlled trial was done in 100 older men and women with untreated elevated BP.[93] The intervention group replaced over half of the daily salt intake in foods and at the table by a mineral salt that contained 41% sodium chloride, 41% potassium chloride and 17% magnesium salts. Urinary sodium excretion decreased by 28% and potassium excretion increased by 22%. The net BP effect was -7.6/-3.3 mmHg after 8 weeks of intervention, which persisted throughout the study period (24 weeks).[93]

In China, a double-blind randomized controlled trial was conducted among rural hypertensive Chinese persons with a reduced-sodium, high-potassium and magnesium salt substitute for 12 months.[94] The salt substitute consisted of 65% sodium chloride, 25% potassium chloride and 10% magnesium sulphate. The mean overall difference in systolic BP between the randomized groups during 12 months follow-up period was 3.7 mmHg ($p<0.001$) and systolic BP was significantly lower in the salt-substitute group than in normal salt group at the 6, 9, 12 month. There was strong evidence that the magnitude of this reduction increased over time with the maximum net reduction of 5.4 mmHg (2.3–8.5 mmHg) in systolic BP achieved at 12 months. However, there was no detectable effects on diastolic BP.[94] Another randomized trial used the same salt substitution in a rural north Chinese population. For normotensive subjects, the net BP effect at 24-month follow-up was -2/-2 mmHg.[95] For subjects with hypertension, the effect on systolic BP was -4 mmHg, with no effect on diastolic BP.[95]

In a Japanese study, Kawasaki et al. studied the BP effect of a sodium-reduced, potassium- and magnesium-enriched mineral salt in 41 Japanese subjects with mild hypertension.[96] Sodium contents in low-sodium seasonings compared to common salt were 59% in table salt, 79% in soy sauce and 67% in miso. Potassium contents in low-sodium seasonings were

77.8 times (table salt), 3.97 times (soy sauce) and 7.63 times (miso) higher than those in normal seasonings. In the mineral salt group BP decreased significantly from 134.7/77.2 at baseline to 127.3 /73.5 mmHg at the end of the intervention period (week 5). BP reductions were larger in hypertensive subjects than in normotensive subjects.[96] Nakamura et al. examined the BP effect of low sodium soy sauce and miso (fermented soybean paste) in 64 Japanese subjects aged 20 years and older.[97] Low-sodium soy sauce and miso were approximately 25% and 20% lower in salt content than common soy sauce and miso. A 6.4 mmHg net reduction in diastolic BP was observed with a salt intake reduction of approximately 10% in the low-sodium seasonings group. However, no significant change in systolic BP was noted which is inconsistent with the previous study.[97]

From these RCTs, the combination of reduced sodium and increased potassium and/or magnesium intake through reformulated salt or other seasonings seems to have a greater effect on BP reduction than sodium reduction alone.

3 RATIONALE AND AIM OF THIS THESIS

Currently, there are only limited data on the national prevalence of hypertension and its risk factors in Vietnam. Furthermore, the prevalence of prehypertension, which is important for early prevention of hypertension and CVD, has not been reported in Vietnam. Also information on sodium intake and dietary sodium sources is lacking, and the prevalence and trend of overweight and obesity, important risk factors for hypertension, are not adequately documented.

As in other Asian countries, food preparation and eating habits may contribute to the main source of dietary sodium. Therefore, reducing sodium intake from salt and condiments added during food preparation, cooking and at the table may be a cost effective strategy for lowering BP in Vietnam. Nutrition education to achieve this, however, takes a long time and is challenging since it involves behavioral changes, particularly changes in eating habits. The use of sodium-reduced and potassium-enriched substitutes for salt and seasonings may be a promising alternative strategy, which has not yet been investigated in the Vietnamese population.

The **aim** of the current thesis is to examine BP and its determinants in the Vietnamese population as well as to investigate a potential population-based intervention for BP control in Vietnam.

More specifically, the following research questions are addressed:

1. What is the prevalence of hypertension and prehypertension and its related risk factors in the general population of Vietnamese adults? (**Chapter 2**)
2. What is the trend of BMI distribution and national prevalence of overweight and obesity in Vietnamese adults? (**Chapter 3**)
3. What is the sodium intake in Vietnam, and which are the main dietary sodium sources? (**Chapter 4**)
4. Does consumption of sodium-reduced and potassium-enriched salt and seasoning in replacement of regular salt and seasoning lower sodium intake and BP in Vietnamese adults with prehypertension and hypertension? (**Chapter 5**)

In **Chapter 6**, the main findings are summarized and interpreted, followed by a discussion of methodological aspects of the studies, future research directions, and the relevance for public health.

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Chapter 2

National prevalence and associated risk factors of hypertension and prehypertension among Vietnamese adults

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ABSTRACT

Background Hypertension has recently been identified as the leading risk factor for global mortality. This study aims to present the national prevalence of hypertension and prehypertension, as well as their association with determinants, in Vietnamese adults.

Methods and results Nationally representative data were obtained from the National Adult Overweight Survey 2005. This one visit survey included 17,199 subjects aged 25–64 years, with a mean BMI of 20.7 kg/m^2. The overall census-weighted JNC7-defined prevalence of hypertension was 20.7% (95% CI 19.4–22.1); the prevalence of prehypertension was 41.8% (95% CI 40.4–43.1). Hypertension and prehypertension were more prevalent in men than in women. Higher age, overweight, alcohol use (among men) and living in the rural areas (among women) were independently associated with a higher prevalence of hypertension, whereas higher physical activity and education level were inversely associated. Age, BMI, and living in the rural areas were independently associated with an increased prevalence of prehypertension. Among the hypertensives, 25.9% were aware of their hypertension, 12.2% were being treated, and 2.8% had their blood pressure under control; among the treated hypertensives, 32.4% had their blood pressure under control.

Conclusion Hypertension and prehypertension are prevalent in Vietnam but hypertension awareness, treatment, and control is low. Population-based intervention aimed at lifestyle modifications including the prevention and reduction of overweight and the promotion of physical activity particularly in urban areas, the reduction of high alcohol consumption, and health education and health care reform are needed for hypertension and control in Vietnam.

INTRODUCTION

Hypertension has been identified as the third leading risk factor for global burden of disease and the main risk factor for mortality.[1,2] It is the most important modifiable risk factors for coronary heart disease, stroke, congestive heart failure, and end-stage renal disease.[2]

The incidence of cardiovascular diseases (CVDs) is especially increasing in the emerging economies.[3] Vietnam is such an emerging economy, currently now including more than 80 million inhabitants. In Vietnam, a number of nutrition-related chronic diseases such as overweight and obesity, hypertension, cardiovascular diseases and type 2 diabetes are rising steadily.[4] Hypertension data has not been well documented in Vietnam, and the published prevalence rates have mainly been derived from small surveys.[5,6] The most recent paper reported an overall prevalence of 25.1% based on pooling of several small surveys carried out in the period 2002–2008.[7] Among the hypertensives, 48.4% were aware of their high blood pressure, 29.6% reported treatment and 10.7% had achieved blood pressure control. Control of hypertension should be achievable in Vietnam as many effective and low-cost treatments are currently available. Prevention of hypertension and controlling prehypertension by non-medical means will also contribute to lessening the burden of CVDs.[8] However information on the determinants and risk groups in the Vietnamese population is currently limited.

This study aims therefore to present the national prevalence of prehypertension and hypertension, and their determinants, as well as levels of awareness, treatment, and control, based on a large nationally representative sample of Vietnamese adults examined in 2005. The findings of this study will provide input for the planning of hypertension prevention and control in Vietnam.

METHODS

Subjects and sampling

The National Adult Overweight Survey, was conducted by the National Institute of Nutrition of Vietnam in 2005, used a stratified two-stage sample design to obtain a nationally representative sample of adults aged 25–64 years. The sample was selected independently within each of Vietnam's eight ecological regions. In the first stage, a total of 240 clusters, each composed of about 100 households, was selected. Within the list of clusters, based on a 3% sample frame for each region and using sampling method of probability proportional to size, 30 clusters were randomly selected from provinces within the region. Urban and rural areas were defined as indicated in the General Statistics Office's Vietnam List of Administrative Divisions. In rural areas, most residents gain their livelihood from agriculture. In the second sampling stage, 72 participants aged 25–64 years were randomly selected in each cluster and categorized equally into four age-groups (25–34, 35–44, 45–54, 55–64) and both sexes. About 3% of those selected were unavailable for the survey, and they were replaced by other randomly selected participants. Data were available of 17,199 adults, aged 25 to 64 years.

Blood pressure measurement

Blood pressure (BP) was measured by well-trained health workers using standard mercury sphygmomanometer in accordance with WHO STEPS manual[9] and adapted by the Vietnam National Cardiology Association.[10] Participants were seated for at least 15 minutes after which BP was measured twice in mmHg. A third measurement was taken if the difference between 2 measurements was ≥10 mmHg, and the average of the second and the third measurements was used for analysis. Hypertension was defined as systolic BP (SBP) ≥140 mmHg and/or diastolic BP (DBP) ≥90 mmHg and/or self-reported current use of anti-hypertensive medication. Prehypertension was defined as SBP ≥120 and <140 mmHg and/or DBP ≥80 and <90 mmHg, and normotension as BP values below 120/80 mmHg according to JNC7.[11] An additional classification of prehypertension as SBP ≥129 and <140 mmHg and/or DBP ≥85 and <90 mmHg was presented according to the 2013 ESH/ESC (European Society of Hypertension/ European Society of Cardiology) guideline.[12] Awareness of hypertension was defined as self-report of previous diagnosis of hypertension by a healthcare professional. Treatment of hypertension was defined as self-report use of anti-hypertensive medication during the 2 weeks prior to the physical examination. Control of hypertension was recorded when the treated hypertensives had SBP/DBP <140/90 mmHg.

Data collection on risk factors

Data collected on risk factors was in accordance with the WHO STEPS manual.[9] Demographic and lifestyle factors (alcohol consumption, smoking, physical activity) were obtained by personal interview using the adjusted WHO STEPS questionnaire. Education levels ranged from illiterate, literate (bur primary school not finished), primary school, secondary school, high school and higher education. Data on physical activity at work, leisure time, daily transportation and sedentary behaviors were analyzed using MET (Metabolic equivalent)-minutes/week based on the Global Physical Activity Questionnaire as recommended by WHO.[13] Physical activity was classified as low, moderate and high if any combination of walking, moderate- or vigorous-intensity activities achieving a minimum of less than 600 MET-minutes per week, at least 600 but less than 3000 MET-minutes per week and 3000 MET-minutes per week accordingly. Physical activity based on combined MET, was classified into quartiles for use in logistic regression analysis. Alcohol intake (beer, spirits, and wine) was converted to gram of ethanol. People who had drunk alcohol within six months prior to the survey date were classified as alcohol drinkers. Smoking was classified as never-smoker, ex-smokers and current smokers. Body weight was measured using SECA electronic scale of 100g accuracy. Body height was measured using wooden stadiometer of 1 mm accuracy. Body mass index (BMI) was computed as weight per height square (kg/m^2). Underweight, normal weight and overweight were defined as BMI below 18, 18–23, 23 and higher, respectively, as recommended for Asian populations.[14] Additionally, BMI of 25 kg/m^2 and higher was used to facilitate international comparison regarding overweight.[9]

Statistical analysis

Data analysis was done using BMI-SPSS statistics 20. The complex sample procedure using weighing factors based on the population structure stratified by ecological region, sex, age-group and area of residence in 2004 (Census, 2004)[15] was applied in order to ensure a fully national representative reporting of the result. Thirty-two participants with extreme height or weight and 4 subjects without blood pressure measurement were excluded. The data therefore were available for 17,199 subjects aged 25–64 years. They were presented as percentages with 95% confidence interval (95% CI) for the prevalence of prehypertension, hypertension, awareness, treatment, and control.

The size of the hypertensive population was estimated as the product of the prevalence of hypertension of x number of population aged 25–64 years. Multiple multinomial logistic regression analysis for polytomous outcomes was performed to analyze the relationship of related factors with both pre-hypertension and hypertension as compared to normotension (exclusion or inclusion of participants taking anti-hypertensive medication – which may have altered their lifestyle – made no significant difference to the result. The multiple logistic regression models included the risk factors such as age, area of residence, education level, alcohol drinking, tobacco smoking, physical activity, and BMI. In the regression model for women, smoking and alcohol drinking were excluded because of the low incidence of their alcohol consumption (3.5%) and tobacco use (2.3%) among women. Odds ratios (ORs) were presented with 95% CI. P-values for trend were also obtained from the regression models.

Ethical consideration

The Ethics committee of the National Institute of Nutrition of Vietnam approved the study. Prior to the data collection, participants were asked for agreement to participate.

RESULTS

Of the 8474 men and 8725 women who participated in the study, 87% were rural residents. Mean age was 44 years (range 25–64 years) (Table 2.1). Men had higher mean systolic BP (126.0 mmHg vs. 120.4 mmHg), diastolic BP (80.7 mmHg vs. 76.6 mmHg) and BMI (20.6 kg/m^2 vs. 20.8 kg/m^2) than women. Most of the men smoked (82.7%) whereas very few women (2.2%) did. Alcohol was consumed by 40.2% of the men and only 3.5% of the women. The majority of the men and women were highly active.

Prevalence of hypertension and prehypertension

The prevalence of hypertension was 20.7% (95% CI 19.4–22.1), and was higher in men as compared to women (25.2% vs. 15.9%, p<0.001), but similar in the urban as compared to rural areas (Figure 2.1). The prevalence of known hypertension was 5.4%, highest in urban men (9.6%) and lowest in rural women (4.3%). The overall prevalence of unknown hypertension was 15.4%, highest in rural men (19.4%) and lowest in urban women (7.8%).

Prehypertension affected 41.8% of the population (95% CI 40.4–43.1), was more prevalent in men compared to women (46.1% vs. 37.2%, p<0.001) and more prevalent in the rural area compared to the urban area (43.0% vs. 33.6%, p<0.001). Only 28% of men and 47% of women had normal blood pressure levels.

Hypertension strongly increased with age (Table 2.2). Overweight men and women had higher prevalence of hypertension (42.8% and 29.1% when overweight defined as BMI ≥25 kg/m^2 or 50% and 34.9% with BMI ≥23 kg/m^2) than normal weight and underweight men and women, respectively. High alcohol consumption was associated with hypertension in men (30.6%) but not in women.

Table 2.1 Selected characteristics of the study population (Vietnam National Adult Overweight Survey, 2005)

Characteristic	Men (N=8474)		Women (N=8725)		P-values	Overall (N=17199)	
Age (year, Mean ± SD)	44.2 ± 11.3*		44.1 ± 11.2		0.477	44.12 ± 11.27	
Systolic blood pressure (mmHg, Mean±SD)	126.0 ± 18.3		120.4 ± 18.5		0.000	123.16 ± 18.59	
Diastolic blood pressure (mmHg, Mean±SD)	80.7 ± 12.1		76.6 ± 11.6		0.000	78.61 ± 12.01	
BMI (kg/m^2, Mean±SD)	20.6 ± 2.6		20.8 ± 2.9		0.000	20.73 ± 2.74	
BMI (kg/m^2; n, %)					0.000		
BMI<18.5	1683	19.9	1855	21.9		3538	20.9
18.5≤BMI<23	5393	65.6	5081	60.0		10474	62.9
BMI≥23	1398	14.5	1789	18.1		3187	16.3
BMI≥25	540	5.3	786	8.0		1326	6.6
	1683	19.9	1855	21.9			
Area (n, %)					0.507		
Urban	2002	13.3	2065	13.2		4067	13.2
Rural	6472	86.7	6660	86.8		13132	86.8
Education (n, %)					0.000		
Illiterate	484	4.7	1189	10.3		1673	7.3
Literate (Primary school not finished)	1237	14.2	1901	21.5		3138	17.7
Primary school	1553	21.2	1593	21.9		3146	21.5
Secondary school	3240	41.5	2540	34.2		5780	38.0
High school	1226	15.6	789	10.4		2015	13.1
Higher education	281	2.9	166	1.8		447	2.4
Alcohol drinkers (n, %)	3335	40.2	396	3.5	0.000	3731	22.5
Smokers (n, %)					0.000		
Current smokers	5275	66.1	266	1.7		5541	34.8
Ex-smokers	1526	16.6	73	.5		1599	8.8
Never-smokers	1550	17.3	8356	97.7		9906	56.4
Physical activity (n, %)					0.000		
Low	1066	10.9	770	7.9		1836	9.4
Moderate	853	9.5	815	8.8		1668	9.2
High	6553	79.6	7139	83.3		13692	81.4

*Mean±SD.

Overall, prehypertension and hypertension combined affected 62.5% of adults aged 25–64 years old and increased with age (from 52.0% in 25–34 years to to 80.4% in 55–64 years).

Under the 2013 ESH/ESC guideline12 rather than the JNC7,11 the prevalence of prehypertension was considerably lower, i.e., 13.7% (95% CI 12.6–14.9) in men and 9.8% (95% CI 8.9–10.8) in women, and the total prevalence of combined prehypertension and hypertension was 32.9% (95% CI 31.3–34.6).

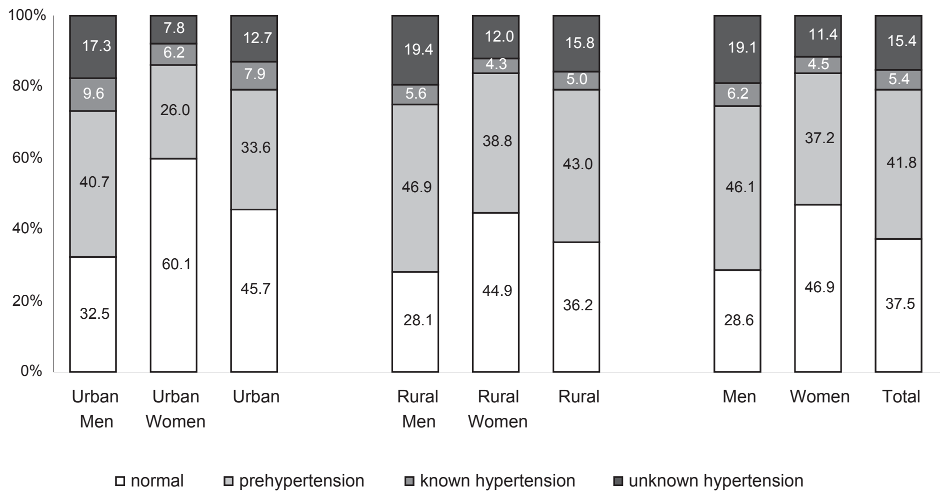

Figure 2.1 Blood pressure distribution by sex and area of residence in Vietnam (National Adult Overweight Survey 2005).
Normal: systolic BP <120 mmHg and diastolic BP <80 mmHg; Prehypertension: systolic BP = 120–139 mmHg and/or diastolic BP = 80–89 mmHg; Hypertension: SBP ≥140 mmHg and/or diastolic BP ≥90 mmHg or anti-hypertensive treatment. Known hypertension: hypertension awareness based on self-report of previous diagnosis of hypertension by a health care professional. Unknown hypertension: hypertension not previously diagnosed by a health care professional.

Determinants of hypertension and prehypertension

The results from multivariable multinomial regression analysis (Table 2.3) showed that age, educational level, BMI and physical activity were independent risk factors for hypertension in both men and women. Alcohol consumption was also an independent determinant of hypertension in men. Men who consumed less than 10 g ethanol/day were less likely to have hypertension (OR 0.74, 95% CI 0.52–0.94) while those with consumption of more than 30 g ethanol/day had an OR of 1.57 (95% CI 1.23–2.02) as compared to the non-drinkers. The differences in hypertension according to smoking habits were reduced after adjustment. After taking into account all other risk factors, women from the rural areas still had significantly elevated hypertension prevalence as compared to urban women.

After adjustments, age and BMI were independently associated with an increased risk of prehypertension, similar to the association with hypertension (Table 2.3). Independent of other risk factors, living in the rural area remained significantly associated with increased risk of prehypertension. Additional analyses showed that under stricter definition of prehypertension, as described above, associations with determinants were similar, but with ORs being slightly higher.

Table 2.2 Prevalence (%) of hypertension and pre-hypertension prevalence (95% CI) by sub-groups (Vietnam National Adult Overweight Survey, 2005)

Subgroups	Men (N=8474)		Women (N=8725)		Total
	Prehypertension*	Hypertension**	Prehypertension*	Hypertension**	Prehypertension and Hypertension
Total	46.1 (44.5–47.8)	25.2 (23.5–27.1)	37.2 (35.4–39.0)	15.9 (14.7–17.2)	62.5 (60.7–64.3)
Age group (year)					
25–34	50.6 (48.0–53.2)	13.8 (11.8–16.1)	32.8 (30.0–35.8)	4.6 (3.6–6.0)	52.0 (49.6–54.4)
35–44	47.1 (44.1–50.1)	24.1 (21.5–26.9)	38.9 (36.1–41.7)	12.1(10.3–14.2)	61.0 (58.7–63.3)
45–54	42.4 (40.1–44.7)	33.4 (30.8–36.1)	39.5 (37.1–42.0)	26.5 (24.0–29.2)	71.0 (68.8–73.1)
55–64	37.3 (35.1–39.6)	46.4 (43.6–49.2)	39.0 (36.5–41. 5)	37.6 (35.0–40.3)	80.4 (78.6–82.0)
Area of residence					
Urban	40.7 (36.7–44.7)	26.9 (23.7–30.3)	26.0 (23.1–29.2)	13.9 (11.8–16.3)	54.3 (51.1–57.5)
Rural	46.9 (45.1–48.8)	25.0 (23.0–27.1)	38.8 (36.8–40.9)	16.2 (14.9–17.7)	63.8 (61.7–65.8)
Education					
Illiterate	47.6 (40.9–54.3)	27.3 (20.6–35.3)	41.7 (37.7–45.9)	23.5 (19.7–27.9)	68.5 (63.9–72.6)
Literate	47.4 (43.6–51.1)	28.2 (24.6–32.1)	36.7 (34.0–39.6)	22.7 (20.1–25.5)	66.2 (63.5–68.8)
Primary school	46.2 (43.0–49.4)	25.7 (22.7–29.0)	36.6 (33.3–40.1)	13.2 (11.3–15.4)	61.1(58.4–63.8)
Secondary school	46.4 (44.1–48.7)	23.5 (21.3–25.8)	39.1 (36.0–42.2)	14.0 (12.1–16.0)	62.6 (60.3–64.9)
High school	45.5 (41.8–49.2)	24.6 (21.4–28.0)	32.8 (28.7–37.3)	11.4 (9.0–14.3)	60.3 (57.3–63.1)
Higher education	45.4 (38.4–52.5)	21.8 (16.5–28.3)	25.4 (18.0–34.5)	4.4 (2.4–7.8)	53.7 (48.8–58.5)
BMI (kg/m^2)					
BMI<18.5	45.6 (42.1–49.1)	18.6 (16.0–21.6)	32.9 (30.0–36.0)	8.4 (7.0–10.1)	52.6 (49.8–55.4)
18.5≤BMI<23	46.9 (44.9–48.9)	23.4(21.4–25.4)	38.2(35.9–40.5)	14.7(13.3–16.1)	62.2 (60.2–64.2)
BMI≥23	43.3(39.6–47.2)	42.8(38.7–46.9)	38.9(35.9–42.1)	29.1(26.3–32.3)	76.4(73.9–78.8)
BMI≥25	40.7 (35.2–46.4)	50.0 (44.3–55.6)	38.2 (34.1–42.6)	34.9 (30.6–39.5)	80.4 (77.3–83.2)

Table 2.2 continues on next page

Table 2.2 *Continued*

Subgroups	Men (N=8474)		Women (N=8725)		Total
	Prehypertension*	Hypertension**	Prehypertension*	Hypertension**	Prehypertension and Hypertension
Alcohol drinking (g Ethanol/day)					
No alcohol	45.7 (43.6–47.7)	25.1 (23.1–27.2)	36.9 (35.1–38.7)	15.8 (14.6–17.1)	59.9 (58.0–61.8)
<10g by men / drinking by women	47.6 (44.0–51.3)	19.4 (16.3–22.9)	44.3 (37.9–50.9)	19.2 (15.3–23.9)	66.3 (62.1–70.2)
Above 10g–30g	49.4 (45.2–53.7)	24.3 (20.2–29.0)			73.7 (69.2–77.8)
Above 30g	44.6 (41.3–47.9)	30.6 (27.1–34.4)			75.2 (72.4–77.8)
Smoking					
Never-smokers	48.0 (44.8–51.3)	23.8 (20.9–26.9)	37.0 (35.2–38.8)	15.9 (14.7–17.1)	55.9 (53.7–58.0)
Current smoker	45.9 (44.0–47.8)	24.5 (22.5–26.6)	40.3 (32.9–48.1)	17.5 (11.2–26.3)	70.1 (67.9–72.2)
Ex-smoker	44.9 (41.5–48.3)	29.7 (26.6–33.0)	38.7 (25.7–53.6)	16.4 (9.4–27.1)	74.0 (70.8–77.1)
Physical activity					
Quartile 1	43.1 (39.9–46.3)	32.0 (29.0–35.2)	33.2 (30.6–36.0)	21.3 (19.0–23.8)	64.9 (62.2–67.5)
Quartile 2	46.2 (43.3–49.1)	26.1 (23.3–29.1)	36.5 (33.9–39.1)	15.3 (13.6–17.2)	62.6 (60.1–65.2)
Quartile 3	46.1 (43.1–49.0)	24.2 (21.6–26.9)	38.5 (35.9–41.3)	15.0 (13.0–17.1)	62.9 (60.4–65.4)
Quartile 4	48.1 (45.4–50.8)	20.7 (18.5–23.2)	40.8 (37.5–44.2)	11.4 (9.6–13.5)	59.8 (57.1–62.4)

BMI, Body Mass Index; CI, Confidence Interval.
*Prehypertension: systolic BP = 120–139 mmHg and/or diastolic BP = 80–89 mmHg.
**Hypertension: Systolic BP ≥140 mmHg and/or diastolic BP ≥90 mmHg or anti-hypertensive treatment.

Table 2.3 Odd ratios (95% CI) from multiple multinomial logistic regression analysis of hypertension and pre-hypertension on selected risk factors (Vietnam National Adult Overweight Survey, 2005)

	Adjusted OR (95% CI)			
Subgroups	Men (N=8474)		Women (N=8725)	
	Pre-hypertension	Hypertension	Pre-hypertension	Hypertension
Age group (year)				
25–34	1.00	1.00	1.00	1.00
35–44	1.13 (0.98–1.31)	2.1 (1.69–2.61)*	1.41 (1.20–1.65)*	2.96 (2.15–4.08)*
45–54	1.22 (1.04–1.44)*	3.61 (2.90–4.49)*	2.08 (1.79–2.42)*	8.83 (6.49–12.00)*
55–64	1.58 (1.34–1.87)*	7.31 (5.88–9.09)*	3.20 (2.67–3.84)*	18.38 (13.46–25.09)*
P for trend	<0.001	<0.001	<0.001	<0.001
Area of residence				
Urban	1.00	1.00	1.00	1.00
Rural	1.42 (1.11–1.82)*	1.35 (0.99–1.84)	2.23 (1.72–2.91)*	2.19 (1.55–3.08)*
Education level				
Illiterate	1.00	1.00	1.00	1.00
Literate, PS not finished	1.06 (0.72–1.55)	0.98 (0.60–1.60)	0.71 (0.54–0.94)*	0.65 (0.45–0.93)*
Primary school	0.91 (0.63–1.32)	0.97 (0.58–1.62)	0.71 (0.55–0.92)*	0.54 (0.37–0.79)*
Secondary school	0.85 (0.59–1.22)	0.66 (0.40–1.11)	0.81 (0.62–1.07)	0.59 (0.40–0.86)*
High school	0.80 (0.53–1.20)	0.65 (0.38–1.14)	0.69 (0.50–0.96)*	0.49 (0.30–0.80)*
Higher education	0.71 (0.43–1.17)	0.38 (0.19–0.75)	0.57 (0.33–0.96)*	0.16 (0.08–0.34)*
P for trend	0.264	<0.01	0.140	<0.001

Table 2.3 continues on next page

Table 2.3 ***Continued***

Subgroups	Adjusted OR (95% CI)			
	Men (N=8474)		Women (N=8725)	
	Pre-hypertension	Hypertension	Pre-hypertension	Hypertension
BMI (kg/m²)				
BMI<18.5	0.73 (0.67–0.92)*	0.57 (0.46–0.69)*	0.64 (0.54–0.75)*	0.38 (0.30–0.48)*
18.5≤BMI<23	1.00	1.00	1.00	1.00
BMI≥23	2.16 (1.65–2.84)*	4.13 (3.04–5.60)*	1.63 (1.35–1.97)*	2.63 (2.15–3.21)*
P for trend	<0.001	<0.001	<0.001	<0.001
Physical activity				
Quartile 1	1.00	1.00	1.00	1.00
Quartile 2	0.97 (0.79–1.18)	0.80 (0.63–1.02)	1.07 (0.09–1.28)	0.76 (0.60–0.97)*
Quartile 3	0.92 (0.74–1.15)	0.75 (0.59–0.95)*	1.15 (0.95–1.41)	0.84 (0.65–1.10)
Quartile 4	0.84 (0.70–1.02)	0.61 (0.48–0.80)*	1.16 (0.95–1.42)	0.70 (0.53–0.92)*
P for trend	0.191	<0.01	0.796	0.053
Alcohol drinking				
No alcohol	1.00	1.00		
≤10g E/day	0.93 (0.76–1.14)	0.73 (0.55–0.98)*		
>10g to 30g E/day	1.18 (0.93–1.50)	1.17 (0.85–1.60)		
>30g E/day	1.11 (0.92–1.34)	1.59 (1.25–2.01)*		
P for trend	0.300	<0.001		
Smoking				
Never-smoker	1.00	1.00		
Ex-smoker	0.92 (0.77–1.11)	0.97 (0.78–1.21)		
Current smoker	1.02 (0.79–1.30)	1.13 (0.86–1.50)		
P for trend	0.283	0.067		

*Statistically significant at $p<0.05$.

2

Hypertension awareness, treatment, and control

Among the group with hypertension, only 25.9% (95% CI 23.3–28.1) were aware of their condition, 12.2% (95% CI 10.7–13.9) were treated, and 2.8% (95% CI 2.1–3.6) had their blood pressure under control (Table 2.4). Thus, 32.4% of the hypertensives had their BP under control. Awareness and treatment increased with age, but the proportionate control among those treated declined strongly with age. Women and urban residents were more aware, treated, and BP controlled than men and rural residents, respectively. The higher the education level people had, the more aware of their hypertension they were.

Table 2.4 Percentage (95% CI) of awareness, treatment and control of hypertension among hypertensive subjects (Vietnam National Adult Overweight Survey, 2005)

Subgroups	Aware	Treated	Controlled	Controlled among Treated
Total	25.9 (23.3–28.1)	12.2 (10.7–13.9)	2.8 (2.1–3.6)	32.4 (27.7–37.5)
Age group (year)				
25–34	18.0 (13.4–23.7)	5.5 (3.4–8.7)	3.0 (1.5–6.1)	72.9 (53.9–86.1)
35–44	21.8 (18.1–26.0)	8.1 (6.0–10.8)	2.8 (1.8–4.5)	47.2 (34.7–59.9)
45–54	28.0 (24.4–32.0)	13.0 (10.6–15.8)	2.1 (1.4–3.3)	25.1 (19.0–32.3)
55–64	33.1 (29.8–36.6)	20.9 (18.4–23.6)	3.4 (2.5–4.6)	19.9 (15.5–25.1)
Gender				
Male	24.4 (21.5–27.5)	9.5 (8.0–11.3)	2.1 (1.5–3.1)	29.7 (24.0–36.0)
Female	28.3 (24.9–32.1)	16.9 (14.3–19.8)	3.8 (2.7–5.2)	34.8 (28.5–41.6)
Area of residence				
Urban	38.4 (32.8–44.3)	18.8 (16.1–21.8)	4.3 (2.8–6.5)	35.0 (26.8–44.3)
Rural	24.0 (21.1–27.0)	11.2 (9.5–13.2)	2.5 (1.8–3.5)	31.7 (26.1–37.8)
Education				
Illiterate	12.4 (7.9–18.8)	10.0 (6.1–16.0)	2.8 (0.9–8.1)	31.6 (13.4–57.9)
Literate – not finish primary school	19.6 (16.4–23.2)	14.6 (11.5–18.5)	3.3 (1.9–5.7)	29.0 (20.8–38.8)
Primary school	20.8 (16.7–25.60	10.8 (8.4–13.7)	2.6 (1.5–4.4)	37.8 (26.8–50.4)
Secondary school	31.0 (27.3–35.0)	12.1 (9.9–14.8)	2.6 (1.7–3.9)	29.4 (22.5–37.3)
High school	36.1 (29.5–43.2)	12.5 (9.4–16.3)	3.2 (1.7–5.8)	41.0 (29.4–53.7)
Higher education	57.9 (43.9–70.8)	14.0 (7.7–24.2)	1.0 (0.1–6.0)	35.9 (17.0–60.5)

DISCUSSION

The result from this National Overweight Adult Survey in 2005 showed that 1 in 5 people aged 25–64 years (20.7%), i.e. more than 8 million Vietnamese adults, was hypertensive. Hypertension was more prevalent in men (25.2%) than in women (15.9%) and higher among older people. This pattern was consistent with the results of several small surveys previously reported in Vietnam.[5,6,16] Son et al.[7] observed a higher prevalence in Vietnam, but they included older people, and non-representative samples including more participants from urban areas. Our national prevalence estimate is comparable to the results in other Asian countries such as China (18%),[17,18] Thailand (21.7%)[19] and South Korea (22.9%).[20] The observed higher prevalence of hypertension in men was consistent with the general picture of sex-difference in other developed and developing countries.[21]

The hypertension prevalence of 20.7% in 2005 was higher than the 16.9% reported in the Vietnam National Health Survey in 2001–2002,[22] indicating an increase in hypertension prevalence among the Vietnamese adults. An increasing trend was also reported in other neighboring countries such as China[23,24] and Thailand,[19] and fit the notion that hypertension is an increasing public health burden in the emerging economies such as in Asia.[25]

The prevalence of prehypertension (41.8%) was as twice that of hypertension, and the current study is the first to report on prehypertension for Vietnam. Prehypertension is an important risk group, as the rate of progression from prehypertension to clinical hypertension was 19% over 4 years[26] and prehypertension is associated with a 66% increase in CVD mortality.[8] A recent review reported that the overall worldwide prevalence of prehypertension as defined by JNC7 is 38%.[27] Chinese studies reported rates ranging from 30.2% to 54.4%, and our result fits well within this range.[27] Using stricter European classification, the prevalence of prehypertension was considerably lower, as expected. It should be noted that our data on hypertension and prehypertension were obtained from two repeated measurements during one visit, while two independent visits are recommended in a clinical setting.[11] It has been shown that with a single visit the prevalence can be overestimated by 3 to 29%.[28] However, other population-based surveys used single visits as well, and hence our results are well comparable with other studies.[19,20,27] Moreover, it has been shown that within-person variation in the outcome variable does not affect the association with its determinants,[29] which is important as these may provide clues for prevention programs.

The positive associations of hypertension with age and BMI and the negative association with educational level and physical activity observed in this national survey were consistent with the results of previous studies in Vietnamese population subgroups[5-7,16] and other countries in the region.[28,30] We have previously shown that the prevalence of overweight in Vietnamese adults was twice as high as in 2005 as compared to 2000.[31] Therefore, this rapid increase in overweight and obesity is likely to partly attribute to a considerable increase in hypertension from 16.9% in 2001–2002[22] to 20.7% in the current study.

Physical inactivity has been documented to be associated with higher risk of hypertension in many populations, also in Asia.[32] In Vietnam, the rapid urbanization and industrialization and modernization have brought its population to less physical activity and at work, travelling to and from work and at leisure, and more sedentary lifestyle. Indeed, 81.4% of our population was classified as having a high level of physical activity, but this was only 56.5% in the urban areas (data not shown). Together with changes in the dietary pattern this induced overweight and obesity[33] and is also independently associated with increased risk of hypertension, as our results suggest. Systematic overviews of lifestyle interventions showed that exercise was associated with a 2.8 to 4.6 mmHg reduction in systolic blood pressure.[34] Each five kilogram of weight loss reduces systolic BP with 3.6 mmHg on average.[34] Therefore promoting physical activity and weight control probably is a good option for the Vietnamese situation as well.

Among men we observed a J-type of association between alcohol consumption and hypertension, indicating that hypertension was higher in those with higher alcohol use, but not in those with moderate alcohol consumption. This has also been reported in other populations.[35,36] Alcohol intake was associated with lowering of blood pressure in several randomized clinical trials.[34] Therefore, lowering alcohol consumption in excessive alcohol drinkers should be promoted for hypertension control in Vietnamese men.

Hypertension was more common in ex-smokers, which was also reported in Vietnamese adults.[35] However, the association between hypertension and smoking was not observed after taking other risk factors, such as BMI, into account. The absence of an association between hypertension and smoking after adjustment for other risk factors was also reported in other populations.[20,21,30]

In many countries, hypertension seems to be more common in urban than in rural areas due to their higher prevalence of overweight and obesity and lower levels of physical activity in urban area.[37] Given these risk factors and also smoking, alcohol use, and education, the prevalence of hypertension and prehypertension was higher in rural residents, especially women. Smaller or no gaps between urban and rural areas have been observed in Thailand, Korea, and China as well.[19,20,31,38] The 2007–2008 China national survey showed that in economically developed regions, the prevalence of hypertension was significantly higher among rural residents than among urban residents.[38] This situation might due to economic development in rural regions, urbanization and associated lifestyle and diet under insufficient health and nutrition education all together led to higher prevalence of prehypertension and hypertension in rural areas than in urban areas. In the present study, we can only speculate regarding the cause of the higher prevalence in rural areas. Dietary factors could be involved, but we were not able to address high sodium intake and low intake of potassium as risk factors for hypertension. The traditional-style food preparation is still highly prevalent in rural areas, and includes salt for preservation as refrigerators are still not widely used.

Awareness and treatment of hypertension was higher in urban areas, as expected. Overall, awareness (25.9%) and treatment (12.2%, less than half of those aware) were low compared to other countries in the region; in Malaysia (34.6% aware, 32.4% treated);[39] and in Thailand (30.1% aware, and 23.5% treated);[19] and comparable in China (24% aware, 18% treated).[17] Among those treated, 32.4% had their blood pressure under control, a proportion which was higher in women than in men, and higher in urban than in rural areas. The control rate in Vietnam was similar to that in neighboring countries, 26.8% in Malaysia, 24% in China in 2002, and 36.6% in Thailand.

In conclusion, on the basis of the National survey data 20.7% of the Vietnamese adults had hypertension and an additional 41.8% had prehypertension, indicating that 62.5% of the adult population or more than 23 million people, at risk of CVDs. Among the hypertensive, only 25.9% were aware of their condition, 12.2% were treated, and 2.8% had their blood pressure under control. Population-based interventions aimed at lifestyle modifications including the prevention of overweight, the promotion of physical activity, particularly in urban areas, the reduction of high alcohol consumption, health education and healthcare reform are needed for hypertension control and prevention in Vietnam.

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Chapter 3

Nationwide shifts in the double burden of overweight and underweight in Vietnamese adults in 2000 and 2005: two national nutrition surveys

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ABSTRACT

Background In developing countries, overweight prevalence is increasing while underweight prevalence is still high. This situation is known as the double nutrition burden. Both underweight and overweight are related to increased risk of chronic non-communicable diseases, reduced well-being and quality of life. This study aims to compare the prevalence of overweight and underweight among Vietnamese adults in 2000 and 2005.

Methods The study was based on two nationally representative surveys, the National Nutrition Survey 2000 (14,452 subjects) and the National Adult Obesity Survey 2005 (17,213 subjects). Adults aged 25–64 years were sampled to be nationally representative. Multiple multinomial logistic regression analysis was used to investigate the association of underweight and overweight with socio-economic indicators.

Results The distribution of BMI across the population and population groups indicated a shift towards higher BMI levels in 2005 as compared to 2000. The nationwide prevalence of overweight (BMI ≥25 kg/m^2) and obesity (BMI ≥30 kg/m^2) was 6.6% and 0.4% respectively in 2005, almost twice the rates of 2000 (3.5% and 0.2%). Using the Asian BMI cut-off of 23 kg/m^2 the overweight prevalence was 16.3% in 2005 and 11.7% in 2000. In contrast, the underweight prevalence (BMI <18.5 kg/m^2) of 20.9% in 2005 was lower than the rate of 25.0% in 2000. Women were more likely to be both underweight and overweight as compared to men in both 2000 and 2005. Urban residents were more likely to be overweight and less likely to be underweight as compared to rural residents in both years. The shifts from underweight to overweight were clearer among the higher food expenditure levels.

Conclusions The double nutrition burden was clearly present in Vietnam. The distribution of BMI across the population groups generally indicated a shift towards higher BMI levels in 2005 as compared to 2000. The prevalence of overweight was increased while the declined level of undernutrition was still high in 2005. The shifts of underweight to overweight were most obvious among population groups with higher food expenditure levels.

BACKGROUND

In developing countries the prevalence of overweight is increasing, while underweight prevalence is still high. This situation is known as the double burden of malnutrition [1]. Although the underweight prevalence is decreasing it is still high, between 20% and 50%, in countries such as India, Bangladesh, China, Philippines, Thailand and Vietnam. Undernutrition is associated with increased comorbidities such as osteoporosis and diabetes [2,3]. Underweight reproductive-age women have increased risks of infertility, pregnancy complications, and giving birth to stunted and thin babies who are more likely to suffer from the diet-related diseases that were formerly thought to be associated with increasing affluence, such as diabetes, coronary heart disease and hypertension. Malnourished adults have lower work output in physical labour, earn less at work, are less productive, and are less likely to be hired as daily wage labour compared to better nourished adults [3].

On the other hand overweight and obesity are increasing, particularly in urban areas [4,5]. Overweight and obesity are regarded as severe risk factors for a number of non-communicable diseases such as type 2 diabetes, cardiovascular disease and several forms of cancer [6]. It was estimated that only 20% of chronic disease deaths occurred in high income countries – while 80% occurred in low and middle income countries, where most of the world's population lives [7]. Controlling, or better even, preventing overweight and obesity is regarded essential in the prevention of non-communicable chronic diseases. Generally, it is clear that double burden of nutrition needs to be investigated and controlled.

Vietnam is a developing country located in South East Asia. The country covers an area of 331,000 square km, of which three fourths are highlands and mountains. With its natural characteristics, Vietnam is divided into eight ecological regions. The population increased from 77.6 million in 2000 to 83 million in 2005, with a decrease of its inhabitants living in rural areas from 76% to 73% [8]. Over the period of 1993–2004, Vietnam was considered as one of the best performers in the world in terms of economic growth [9]. Parallel with socio-economic development, the dietary pattern and lifestyle of the Vietnamese population has been changing. The composition of the diet shifted to lower amounts of starchy staples and higher amounts of proteins and lipids (meat, fish, other protein-rich or high fat foods) [10]. The higher level of industrialization and modernization brings a lifestyle with less physical activity and more sedentary habits. As a result, Vietnam is now in a period of nutrition transition and faces a double burden of nutritional problems, both underweight and overweight [11,12], similar as to other countries in the area.

In Vietnam, the problem of underweight or overweight have been studied mainly in specific groups such as children and reproductive age women and with small scale studies [13]. Surveys on overweight and obesity have reported a range of adult overweight prevalences from 8% to 18% in the period 1999–2003 [14-16]. These findings do not allow drawing nationwide conclusions on nutritional status of adult population. Two studies documented differences in the period 1992–2002, observing a reduction in underweight in adults aged 18–65 years, from 31.2% in 1992 to 24.3% in 2002, and an increase in overweight from 2% to 5.2% over this ten-year period [11,17]. The current paper aims to compare the prevalence of overweight and underweight among Vietnamese adults in 2000 and 2005, using the most updated nationally representative data of the National Nutrition Survey in 2000 (NNS 2000) and the National Adult Obesity Survey in 2005 (NAOS 2005). Given the strong economic development we expect to observe considerable changes.

METHODS

Subjects and sampling

For this paper, data from the National Nutrition Survey in 2000 (NNS 2000) and the National Adult Obesity Survey in 2005 (NAOS 2005) were used. Both surveys used a stratified two-stage sample design.

In short, the sample was selected from the 3% household sample frame of the National Population and Housing Census (NPHC) in 1999, which was stratified by ecological regions, provinces and urban-rural area. The sample selection was done independently within each of eight ecological regions. In the first stage, 30 clusters were selected with the systematic random sampling based on the 3% sample frame. In the second sampling stage the sampling was different between NNS 2000 and NAOS 2005. In the NNS 2000, one third of the households in each cluster was selected by systematic sampling and all household members were invited for data collection. In the NAOS 2005, in each cluster 72 subjects aged 25–64 years were selected randomly and equally based on 4 age groups (25–34, 35–44, 45–54 and 55–64 years) and both genders. For both surveys, selected households (NNS 2000) or subjects (NAOS 2005) who were not able to present at the surveys were replaced by other randomly selected households or subjects (with the same gender, age group of the same cluster) based on the available sample frame of each cluster, as recommended [18]. Data were available of 14,452 (NNS 2000) and 17,213 (NAOS 2005) adults, aged 25 to 64 years.

Nutritional status measurement and assessment

Height and weight were measured by standard methods using calibrated instruments [18]. Height was measured by using wooden stadiometer with accuracy at 1 mm. Weight was measured by using SECA electronic scale with accuracy at 100 g. Body mass index (BMI, kg/m^2) was calculated as weight (in kg) divided by body height (in m) squared. Underweight, normal weight, overweight and obesity were classified using BMI cut-off points classified by the WHO: <18.5 kg/m^2 is underweight, 18.5–24.9 kg/m^2 is normal weight, ≥25 kg/m^2 is overweight and ≥30 kg/m^2 is obesity [18]. Additional cut-off points suggested to use for Asian populations were also used, i.e.: ≥23 kg/m^2 for overweight and ≥27.5 kg/m^2 for obesity [19].

Statistical analysis

3

Data analysis was done using SPSS version 15.0 (SPSS Inc. Chicago, Ill). In order to ensure a fully national representative reporting of the result, both datasets were analyzed by the complex sample procedures using weighing factors based on the population structure stratified by ecological region, gender, age group and urban-rural area in 1999 (NPHC, 1999) and in 2004 (Census, 2004) for the datasets of NNS 2000 and NAOS 2005, respectively.

Pregnant women and under-12 month lactating mothers as well as subjects with extreme and/or implausible height, weight or BMI were excluded. In the dataset of NNS 2000, data of 324 pregnant and lactating women and 15 subjects with extreme height or weight were excluded from the analysis. In NAOS 2005 pregnant and under-12 month lactating women were excluded in the sampling procedure. In the data analysis phase 32 subjects with extreme height or weight were excluded. Data were therefore available on 14,452 (NNS 2000) and 17,213 (NAOS 2005) adults, aged 25 to 64 years.

The data are presented as percentages with 95% confidence interval (95% CI), stratified by ecological region, area of residence, age group, gender, education level and food expenditure level. Multiple multinomial logistic regression, logistic regression for polytomous instead of dichotomous outcomes, was used to investigate the relationship of socio-economic factors with both underweight and overweight. Results were presented as odds ratios (OR) with 95% CI comparing overweight or underweight to normal weight. Variables which were available in both datasets were included in the regression models, i.e. age group, gender, area of residence, education level and food expenditure (as income proxy). The food expenditure variable was the average monthly food expenditure per capita (in Vietnam currency). Food expenditure was categorized into 5 levels based on percentiles with level 1 is the lowest and level 5 is the highest. The education levels ranged from illiterate, literate, primary school, secondary school, high school and higher education. The estimation of number of overweight or underweight population was the products of the prevalence of overweight or underweight × number of population aged 25–64 years old.

Ethical consideration

The study was approved by the Ethical committee of the National Institute of Nutrition – Vietnam Ministry of Health. Participants were asked for agreement to participate in the surveys prior to the data collection. Full access to the datasets was approved by the Vietnam National Institute of Nutrition.

RESULTS

Trend of BMI distribution

The distribution of BMI across the whole population and population groups generally indicated a shift towards higher BMI levels in 2005 as compared to 2000 (Table 3.1). Nationwide, the overall prevalence of overweight (BMI ≥25 kg/m^2) and obesity (BMI ≥30 kg/m^2) were 6.6% (95% CI 5.9–7.4%) and 0.4% (95% CI 0.3–0.6%) in 2005, which were almost twice the rates in 2000, 3.5% (95% CI 3.0–4.0%) and 0.2% (95% CI 0.1–0.2%). When applying the suggested cut-off points for Asia, the prevalence of overweight (BMI ≥23 kg/m^2) and obesity (BMI ≥27.5 kg/m^2) were 16.3% (95% CI 15.1–17.5%) and 1.7% (95% CI 1.4–2.0%)

Table 3.1 BMI distribution (%, 95% CI) in adults aged 25–64 years in 2000 and 2005 by gender

	N	BMI <18.5 kg/m^2	BMI ≥23kg/m^2	BMI ≥25kg/m^2	BMI ≥27.5kg/m^2	BMI ≥30kg/m^2
National Nutrition Survey 2000						
Nationwide	14,452	25.0 (23.5–26.5)	11.7 (10.6–12.9)	3.5 (3.0–4.0)	0.9 (0.7–1.1)	0.12 (0.1–0.2)
Male	7,044	22.0 (20.4–23.7)	9.6 (8.4–10.9)	2.8 (2.2–3.4)	0.7 (0.4–1.0)	0.1 (0.0–0.2)
Female	7,408	27.9 (26.0–29.8)	13.7 (12.3–15.3)	5.5 (4.8–6.5)	1.6 (1.2–2.0)	0.2 (0.1–0.4)
National Adult Obesity Survey 2005						
Nationwide	17,213	20.9 (19.6–22.1)	16.3 (15.1–17.5)	6.6 (5.9–7.4)	1.7 (1.4–2.0)	0.4 (0.3–0.6)
Male	8483	19.9 (18.4–21.4)	14.5 (13.2–16.0)	5.3 (4.6–6.1)	1.2 (0.9–1.6)	0.4 (0.2–0.6)
Female	8,730	21.9 (20.4–23.5)	18.1 (16.7–19.7)	8.0 (7.1–9.0)	2.2 (1.8–2.7)	0.5 (0.3–0.7)

in 2005, in comparison with 11.7% (95% CI 10.6–12.9%) and 0.9% (95% CI 0.7–1.1%) in 2000. Based on these data, the average annual increase in overweight prevalence was 0.62%/year. In contrast to the shift to higher overweight and obesity prevalence, the underweight prevalence (BMI <18.5 kg/m^2) showed a lower level in as 2005 compared to 2000, i.e. 20.9% (95% CI 19.6–22.1%) compared to 25.0% (95% CI 23.5–26.5%), respectively. The average annual decrease in underweight prevalence was 0.82%/year. Table 3.1 also shows that both the prevalence of overweight and underweight were higher in women as compared to men in both years.

Concerning area of residence, the shift from underweight to overweight was observed in both urban and rural areas (Figure 3.1). The overweight and obesity prevalence was higher in 2005 as compared to 2000 in both rural and urban areas with, as expected, the highest prevalence in the urban area. The underweight prevalence was lower in 2005 as compared to 2000 in both areas of residence, but always higher in rural area compared to urban area in both years.

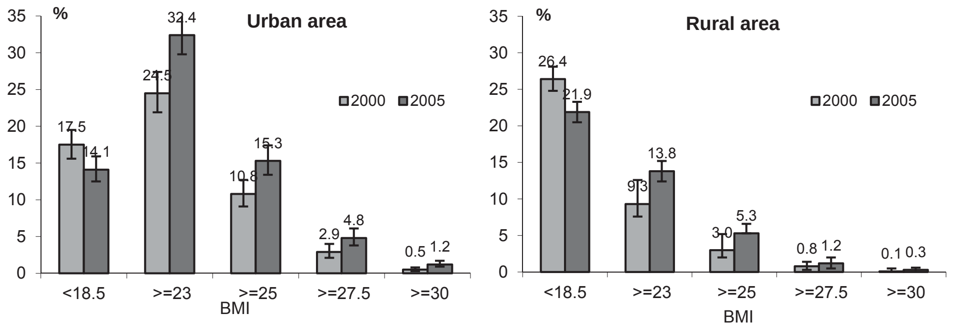

Figure 3.1 BMI distribution (%; 95% CI) in adults aged 25–64 years in 2000 and 2005 by area of residence.

Double burden of overweight and underweight by various subgroups

Figure 3.2 shows the prevalence of overweight across different subgroups of gender, area of residence and age in 2000 and 2005. The general trend of higher rates in 2005 was observed in all subgroups (men and women, urban and rural areas and different age groups). In both areas and genders the prevalence of overweight was generally higher with higher age, with the highest prevalence for age group 45–54 years in both 2000 and 2005.

The underweight prevalence by different subgroups is presented in Figure 3.3. The highest underweight prevalence was observed in the youngest men and women (25–34 years

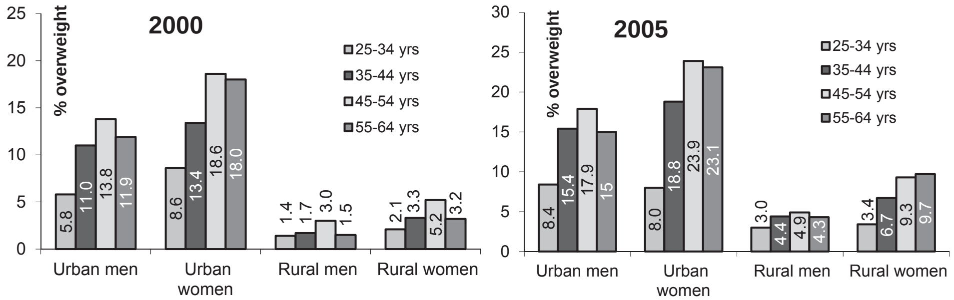

Figure 3.2 Prevalence of overweight (BMI ≥25 kg/m^2) in 2000 and 2005 by age group, sex and area of residence.

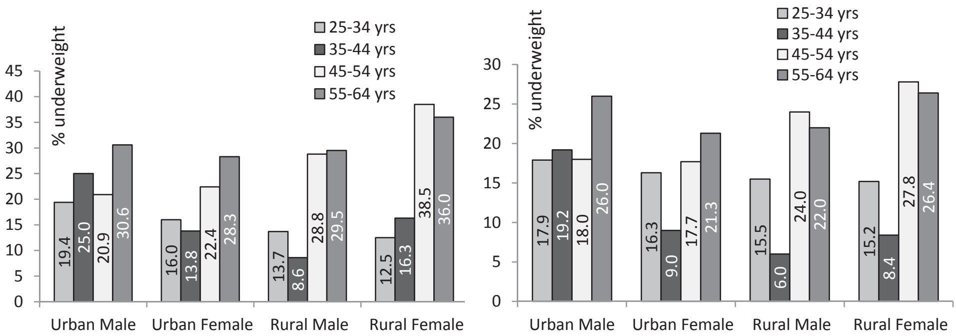

Figure 3.3 Prevalence of underweight (BMI <18.5 kg/m^2) in 2000 and 2005 by age group, sex and area of residence.

old) in the urban area in contrast to the oldest men and women (55–64 years old) in the rural area, although in 2005 the differences were less pronounced as compared to 2000. Among urban men, the underweight prevalence by age was about similar in both years, while among rural men underweight prevalence was lower in 2005 as compared to 2000, similar to the prevalence among urban and rural women.

Generally, underweight was less frequent among the older compared to the younger age groups among urban men, while it was more frequent among higher age groups among rural men. Among urban women, underweight was most prevalent among the youngest group aged 25–34 years. Among rural women, the youngest and the oldest groups were more frequently underweight as compared to the other age groups in both years.

The double burden of overweight and underweight across eight ecological regions in 2000 and 2005 is presented in Figure 3.4. In all ecological regions, the prevalence of overweight

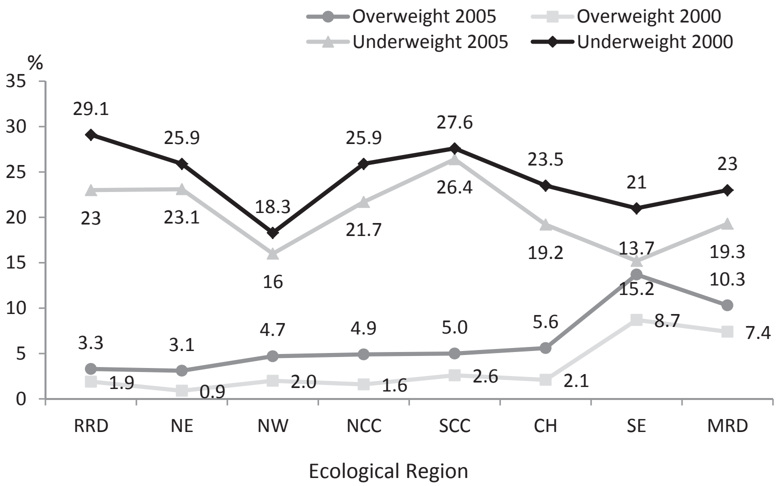

Figure 3.4 Prevalence of underweight (BMI <18.5 kg/m²) and overweight (BMI ≥25 kg/m²) in 2000 and 2005 by ecological region. RRD: Red river delta, NR: Northeast, NW: Northwest, NCC: North Central Coast, SCC: South Central Coast, WH: West Highland, SE: Southeast, MRD: Mekong river delta.

was higher in 2005 as compared to 2000. The pattern of overweight across the regions was similar in both 2000 and 2005. The highest prevalence was found in the South-East and Mekong river delta regions and the lowest prevalence was seen in the North-East region, while the remaining regions did not differ much from each other. The pattern regarding underweight was also similar in both 2000 and 2005. The highest prevalence of underweight was observed in the Red river delta and South Central Coast, while the lowest was found in North-West and South-East regions in both years.

Figure 3.5 shows that there were quite similar patterns regarding the prevalence of overweight and underweight according to education levels in 2000 and 2005. The underweight prevalence was about similar for the four lower education levels and gradually reduced from the of Secondary school level to the Higher education level. This contrast in underweight between lower and higher education levels was larger in 2005 as compared to 2000. The prevalence of overweight gradually increased from the levels of lower education to Secondary school and quickly raised the highest rate at the Higher education level. Also this contrast was larger in 2005 as compared to 2000.

The prevalence of overweight and underweight by food expenditure levels are presented in Figure 3.6. At higher categories of the food expenditure, the prevalence of overweight was higher and the prevalence of underweight was lower, in both years.

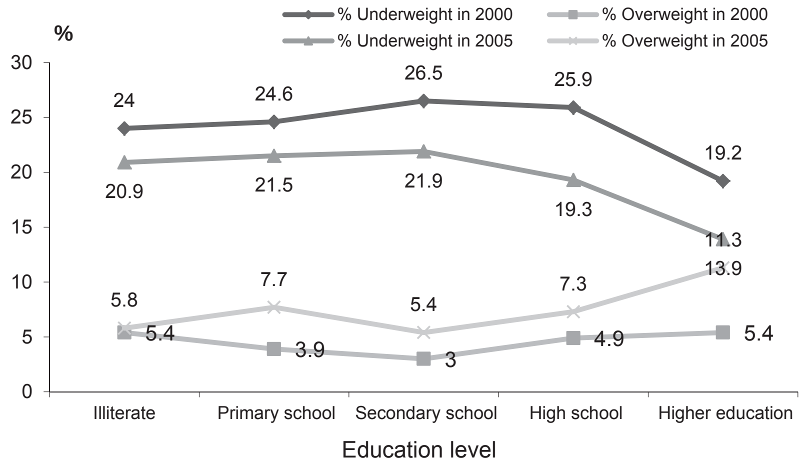

Figure 3.5 Prevalence of underweight and overweight by education level in 2000 and 2005.

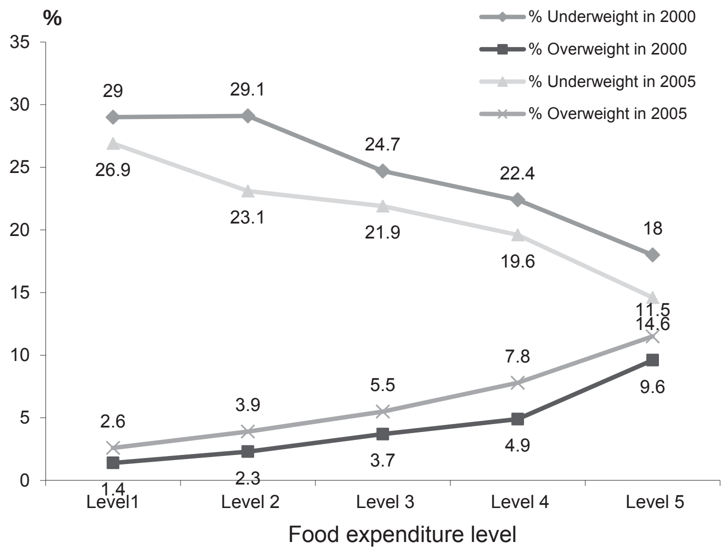

Figure 3.6 Prevalence of underweight and overweight by food expenditure level in 2000 and 2005.

Multiple logistic regression analysis

Table 3.2 presents the independent association of several socio-economic factors with underweight and overweight in both 2000 and 2005, using multiple multinomial logistic regression analysis.

Table 3.2 Relationship of selected socio-economic factors with overweight and underweight in 2000 and 2005

	Adjusted OR (95% CI)					
	2000			2005		
	N	Underweight	Overweight	N	Underweight	Overweight
Age group						
25–34	5,024	1.00	1.00	4,335	1.00	1.00
35–44	5,147	0.95 (0.85–1.07)	1.56 (1.11–2.18)*	4,354	0.85 (0.74–0.97)*	1.95 (1.48–2.57)*
45–54	2,780	1.15 (1.00–1.31)*	2.26 (1.62–3.15)*	4,325	1.10 (0.95–1.27)	2.79 (2.16–3.61)*
55–64	1,501	1.65 (1.38–1.97)*	1.5 (0.92–2.34)	4,199	1.34 (1.15–1.56)*	2.66 (1.99–3.56)*
Gender						
Male	7,044	1.00	1.00	8483	1.00	1.00
Female	7,408	1.46 (1.31–1.63)*	2.03 (1.64–2.52)*	8730	1.16 (1.03–1.31)*	1.53(1.29–1.83)*
Area of residence						
Rural	10,616	1.00	1.00	13,145	1.00	1.00
Urban	3,836	0.76 (0.63–0.92)*	2.39 (1.79–3.19)*	4,068	0.80 (0.64–0.99)*	2.08 (1.60–2.72)*
Education level						
Illiterate	1,239	1.00	1.00	1,675	1.00	1.00
Literate	2,675	1.13 (0.88–1.44)	1.29 (0.82–2.05)	3,139	1.24 (0.93–1.64)	0.73 (0.53–1.01)
Primary school	4,175	1.27 (0.99–1.64)	0.81 (0.5–1.31)	3,151	1.38 (1.03–1.87)*	0.68 (0.45–1.00)
Secondary school	3,920	1.43 (1.07–1.91)*	0.6 (0.37–0.97)*	5,783	1.36 (1.01–1.84)*	0.59 (0.41–0.85)*
High school	1,582	1.62 (1.17–2.26)*	0.69 (0.42–1.13)	2,017	1.30 (0.93–1.81)	0.70 (0.47–1.04)
Higher education	809	1.28 (0.88–1.88)	0.44 (0.25–0.79)*	447	1.07 (0.63–1.08)	0.90 (0.55–1.49)
Food expenditure						
Level 1	2,895	1.00	1.00	2,987	1.00	1.00
Level 2	2,889	1.00 (0.86–1.16)	1.72 (1.06–2.80)*	2,936	0.82 (0.69–0.98)*	1.49 (1.01–2.19)*
Level 3	2,892	0.82 (0.69–0.97)*	2.45 (1.58–3.79)*	2,946	0.75 (0.62–0.89)*	2.09 (1.41–3.11)*
Level 4	2,876	0.75 (0.63–0.89)*	2.94 (1.87–4.62)*	2,943	0.71 (0.59–0.85)*	3.00 (1.98–4.53)*
Level 5	2,890	0.64 (0.54–0.76)*	4.74 (2.95–7.61)*	2,947	0.55 (0.44–0.69)*	3.49 (2.32–5.24)*

OR: odds ratio; CI: Confidence interval. * Significant at p<0.001.

Women were always more likely to be both underweight (OR=1.4 and OR=1.16 in 2000 and 2005, respectively) or overweight (OR=2.03 and OR=1.53 resp.). After adjustment for education level and food expenditure level, as proxy for income, urban residents were always less likely to be underweight (OR=0.76 in 2000 and 0.80 in 2005) and more likely to be overweight (OR=2.39 and OR=2.08). Food expenditure level, as proxy for income, was independently associated with underweight and overweight in both years. The higher the food expenditure, and thus the higher the income, the more overweight (OR = 1.72 to 4.74 and OR = 1.49 to 3.49) and the less underweight (OR = 1.00 to 0.64 and OR = 0.82 to 0.55) was observed. Regarding educational level the results were different from the unadjusted analyses as shown in Figure 3.5. After adjustment for food expenditure level, area, age and gender, the higher education groups were generally more likely to be underweight and less likely to be overweight as compared to the lowest education level. This was mainly due to the association with food expenditure level, which was more strongly related to underweight and overweight than education.

DISCUSSION

This study shows that the prevalence of overweight (BMI ≥25 kg/m^2) among Vietnamese adults aged 25–64 years in 2005 was almost twice as compared to 2000. The estimated average increase in prevalence of overweight amounted to 0.6%/year, which was almost twice as that of 0.3%/year over the period of 1992–2002 [11]. Based on our data, the estimated number of subjects aged 25–64 years with overweight in 2005 amounted to about 2.6 million (BMI ≥25 kg/m^2) or 6.5 million (BMI ≥23 kg/m^2).

The pattern of overweight and obesity prevalence across population groups defined by age, gender and/or areas of residence were similar between the two periods (1992–2002 and 2000–2005), with a higher prevalence among women, urban residents, and older age-groups. The higher estimated increase in the nationwide prevalence of overweight and obesity and the bigger differences between urban and rural areas observed in 1992–2002 and 2000–2005 highlights the increasing problem of overweight in Vietnam, particularly in the urban areas.

The increasing trend of overweight and obesity is not only observed in Vietnam but also in other countries in the Asian region as well as worldwide. Fortunately, the magnitude of the problem in Vietnam is still much less than in many of these countries, such as 29% (1996–1997) in Hongkong [20] and 26.7% (1998) in Korea [21], which might be due to lower level of economic development in Vietnam. In Thailand, the National Health Examination Survey II showed a prevalence of overweight (BMI ≥25 kg/m^2) in adults aged 20–59 years of 28%, with highest values in women (33.9%) and in the urban population (34.8%) [22]. The problem of overweight and obesity is also rapidly increasing in China in all gender and age groups and in geographical areas, particularly in the urban area, with overall reported prevalence rates of 15% in 1992 and 22% in 2002 [23]. The higher prevalence of overweight and obesity among women and urban residents in Thailand and China were similar to the situation found in the present study.

The prevalence of urban overweight (BMI ≥25 kg/m^2) in our nationwide samples is in concordance with previous smaller studies done in Hanoi and Ho Chi Minh City which reported overweight in 17.2% to 18.5% of adults aged 20–60 years [14-16]. In the past, the percentage of overweight in the adults, was also higher in urban areas than in rural areas (4.8% vs. 1.2% in 1998 and 9.6% vs. 3.5% in 2002) [17]. This higher prevalence in the urban area may be explained by the faster economic growth. Over the period 1993–2004 Vietnam was considered to be one of the best performers in the world in terms of economic growth [9]. As a result, poverty rates were halved in the same period. The general poverty rates decreased from 37% to 20%, while the food poverty rate went down from 13% to 7%. In parallel with the economic growth, the urbanization went up and the rate of urbanization is expected to remain above 3% per annum until 2020. It was estimated that the urban area accounted for 70% of the growth while containing only 25% of the population [24]. We used food expenditure as a proxy indicator of income, and this was indeed also associated with higher overweight rates. But independent of food expenditure and other demographic factor overweight was still twice as high in urban areas compared to rural areas. In addition to higher income, urbanization has brought changes in lifestyle and food consumption habit which may also contribute to the higher prevalence of overweight. In urban areas of developing countries, food scarcity may no longer be the driving force behind energy intake. Instead, the availability of cheap, energy-dense foods (including those from street vendors and fast food restaurants) may facilitate the consumption of more calories. Widespread access to television would favour an indoor, sedentary lifestyle, further reducing the average daily energy expenditure [25]. Those changes lead to an obesogenic environment.

The prevalences of overweight and obesity differed across the eight ecological regions but were all higher in 2005 as compared to 2000. There were several reasons for these differences and changes, but they were likely to be closely related to socio-economic status.

Household poverty status significantly influences food consumption and food patterns [10]. There were considerable disparities in regional poverty and poverty reduction [9]. The South East region had the lowest poverty rate, which reduced from 12% in 1998 to 5% in 2004, and the same region was shown to have the highest and fastest increase in the prevalence of overweight and obesity. The Northern mountains (North East and North West), the North Central Coast and the Central Highland all have high poverty rates (50% and above in 1998 and still over 30% in 2004) and accordingly have lower prevalence rates of overweight and obesity.

In contrast with the increasing problem of overnutrition, undernutrition showed a decreasing trend. The estimated average annual reduction rate was 0.8%/year in the period 2000–2005, after an earlier reduction of underweight in adults from 31.2% in 1992 to 24.3% in 2002 [11]. This reduction is probably thanks to the economic development and the considerable achievement in nutrition policy and intervention in Vietnam [26]. In our study, food expenditure level was inversely associated with underweight. However, despite substantial improvements in rural living standards, poverty levels were still remarkably high in the rural area [9] in addition to the high prevalence of underweight. In the past decades, the available data showed that the prevalence of underweight and stunting among children aged under 5 years were very high, e.g. 51.5% and 59.7% in 1985, 44.9% and 46.9% in 1994, 31.9% and 34.8% in 2001 [26]. In the earlier decades, a similar or even worse situation probably existed. This early childhood malnutrition situation may contribute to the adult overweight nowadays [27]. Maternal and child malnutrition control should be strengthened to reduce child undernutrition in order to prevent adulthood underweight and overweight, as well as the related chronic diseases.

In terms of age, the highest prevalence of overweight was observed in the age category of 45–54 years. Only for rural women, the age pattern was somewhat different, with the highest prevalence observed in the oldest category (55–64 yrs) in 2005. The general pattern of overweight and obesity by age agrees with survey findings from other Asian countries [28,29]. The prevalence of underweight by age differed between urban and rural areas. In the urban area underweight was more prevalent in the youngest group of 25–34 years, while in the rural areas it was more prevalent in the oldest age groups. This may be explained by the immigration of young labour force from rural to urban areas due to rapid urbanization. Those young workers are mainly unskilled, having heavy manual works with low income. People who move from rural to urban areas usually lose the ability to grow their own food and thus become dependent for their calories on a cash market [25].

Interestingly, women were more likely to be both underweight and overweight as compared to men. This pattern was also reported among Indian women [30] and among Bangladesh rural and urban poor women [31]. This may reflect various disadvantages which women face, such as poor nutrition care, heavy work load, physiological characteristics, and a high prevalence of early childhood undernutrition [3]. Because of women's cyclical loss of iron and childbearing, their nutritional status is particularly vulnerable to deficiencies in diet, care, and health or sanitation services. Gender inequality exacerbates infectious diseases among the less affluent through the pathway of childhood undernutrition. At the same time, it exacerbates the new regime of chronic diseases among the relatively more affluent, possibly through a pathway that has come to be known as "the Barker hypothesis". Gender inequality thus leads to a double jeopardy, aggravating the double nutrition burden [32].

A steady shift is shown between underweight and overweight prevalence according to food expenditure, independent of age, gender and education. These findings confirm the association of economic growth with food consumption and nutritional status, particularly in developing countries where more than 50% of income is spent on food [25]. Interestingly, the observed higher prevalence of overweight and lower prevalence of underweight in the highly educated group was accounted for by the other demographic factors and food expenditure in the logistic regression analysis.

Our results indicate that it is timely and necessary to take immediate action for effective control of underweight and early prevention of the spread of overweight and obesity problem in Vietnam. However, programs and interventions should take the double nutrition burden into consideration to avoid sharpening the severity of underweight when spending efforts in reducing overweight. Appropriate interventions are needed for specific population subgroups. Some important interventions for reducing the rate of undernutrition may also be beneficial in terms of reducing the burden of obesity are promoting breast-feeding, improving nutritional status of women of reproductive age, and reducing the rates of fetal growth retardation [33] and low birth weight [25]. Improving the obesogenic environment in urban area by nutritional education, information and communication for promoting healthy eating and physical activity and monitoring food market should be intensively implemented in order to reducing underweight and preventing overweight [25]. Reducing gender inequalities should be paid attention in improving double burden of nutrition among women in particular and in the whole population in general [33]. Promoting household food production with the existing successful VAC model (i.e. the Vegetation, Aquaculture and Cattle-breeding model), particularly encouraging small-scale farmers and, especially women, to grow and utilize a wide variety of food crops toward improving household food security and dietary diversity can be an effective way for combating double nutrition burden in rural area [34].

The present study has some limitations. Data on diet, physical activity and smoking were not available for both datasets and thus could not be adjusted for. However, with data from the two largest recent nationally representative nutrition surveys, conducted by well trained personnel according to a standardized protocol, the shift in the double burden of malnutrition was clearly demonstrated.

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Authors' contributions

DTPH as a principle investigator of this research have full access to all of the study data and takes responsibility for the integrity of the data and the accuracy of the data analysis; she formulated the research question, participated in data collection, conducted data analysis and wrote the paper. EJMF provided guidance in the formulation of the manuscript, critical revision of the manuscript for intellectual content and take full responsibility for the paper. PD provided methodological expertise, guidance in data analysis and critical revision of the manuscript for intellectual content. LBM was responsible for the formulation of the surveys and data collection. NCK provided guidance in formulation of the surveys, data collection and critical revision of the manuscript for intellectual content. FJK contributed guidance in the formulation of the manuscript and critical revision of the manuscript for intellectual content. All authors read and approved the final manuscript.

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Chapter 4

Sodium intake and its dietary sources in Vietnamese rural adults

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Submitted

ABSTRACT

Objectives Dietary sodium intake in Vietnam is thought to be high, but a valid estimate is lacking so far. This study aims to investigate urinary sodium excretion and dietary sodium sources in a rural population of Vietnamese adults.

Design A cross-sectional survey. Simple random sampling was used to recruit subjects for 24h urine collection and dietary assessment by 24h direct food weighing.

Setting A rural commune of northern Vietnam.

Subjects 121 men and women aged 25–64 years.

Results The mean 24-hour sodium excretion was 188.6 ± 57.5 mmol (4.3 g) or 10.8 ± 3.3 g salt/day. Men had higher mean 24-hour sodium excretion (196.8 ± 56.9 mmol or 4.5 g) as compared to women (181.1 ± 57.4 mmol or 4.2 g); 97.5% of the men and women had a salt intake higher than the WHO recommendation of less than 5 g/day. Sodium in condiments added during cooking or eating at the table accounted for 81% of sodium intake. Processed foods contributed 11.6% and natural foods 7.4%. Regarding the condiments, the largest source was the mixed seasoning ('bot canh', 35.1% of total); 31.6% of total dietary sodium was provided by fish sauce, 7.4% by monosodium glutamate and 6.1% by table salt.

Conclusions Excessive sodium intake did exist in most of the studied population. Reducing sodium intake and particularly limiting condiments added during cooking and at the table, responsible for 81% of total sodium intake, should be given priority in efforts of sodium restriction for control and prevention of hypertension and related diseases.

INTRODUCTION

The morbidity and mortality pattern in Vietnam is rapidly changing, with a decrease in communicable diseases in parallel with an increase in noncommunicable diseases (NCDs).[1] Recent data showed that NCDs accounted for 75% of all deaths, among which cardiovascular diseases were the first causes of death (40%).[2] Hypertension was the most common cardiovascular disease, with a prevalence of 33% in those aged 25 years and older.[2]

The World Health Report reviewed strategies to reduce the risks associated with cerebro-vascular disease and hypertension and stated that in all settings population-wide salt reduction strategies are the most cost-effective.[3] However, salt consumption has rarely been investigated in Vietnam, and no study investigated the dietary sources of sodium, which makes planning of a salt reduction strategy difficult.

So far the INTERSALT study provides the largest set of standardized data on 24-hour urinary sodium excretion patterns around the world.[4] It included 52 population samples in 32 countries in 1985–1987. Highest values of urinary sodium excretion were recorded in Tianjin, China, with 259 mmol/d (5.95 g/d of sodium) in men and 233 mmol/d (5.35 g/d of sodium) in women, and in Toyama, Japan, with 224 mmol/d (5.12 g/d) in men and 201 mmol/d (4.62 g/d) in women. Values over 200 mmol/d (4.6 g/d) in men were also found in Canada, Columbia, Hungary, Ladakh (India), Bassiano (Italy), Poland, Portugal and the Republic of Korea.

Studies published since 1988 showed that most populations appear to have mean sodium intakes well in excess of 100 mmol/d (2.30 g/d), and in many (especially the Asian countries) in excess of 200 mmol/d (4.60 g/d).[5] In addition to information on total sodium intake based on sodium excretion, information on the dietary sources of salt (sodium) plays a critical role in designing proper nutrition guidelines and formulating intervention strategies. Dietary sodium comprises different sources such as natural foods, processed foods, salt and seasoning added to foods during cooking or prior eating at the table. In industrialized countries, most of sodium intake is via the consumption of processed foods and foods eaten out of home, accounting for about 75% of dietary intake.[6] In Asian countries such as Japan and China, however, most of dietary sodium is coming from salt and salty sauces added during cooking or eating.[7]

Therefore, this study aims to investigate the sodium intake and dietary sodium sources in a rural population of Vietnamese adults, in order to provide scientific evidence for salt reduction planning and related non-communicable disease control and prevention.

METHODS

Participants

Participants were 121 adults aged 25–64 years from a rural commune in the northern part of Vietnam. Inclusion criteria were absence of history of chronic kidney or heart diseases, no acute disease at the survey day, no current use of sodium-containing and urination increasing drugs, no sodium-restricted diet upon medical advice, no current pregnancy or 12-month lactation. Simple random sampling within age groups with stratification was used to select studied subjects in order have equal number of subjects by four age-groups (25–34, 35–44, 45–54, 55–64 years) and both sexes.

Data collection

Urinary sodium excretion was assessed by 24-hour urine collection, the gold standard for assessment of sodium intake.[8] Single 24-hour urine samples were collected. The subjects were asked to collect all urine voided during 24 hours. Urine collection ended on the same time of the next day. Instruction for urine collection was given by the research workers to all subjects before the survey day. Detailed written instruction was also handed out. Start time, end time and total 24h urine volume were recorded. At the end of the 24-hour urine collection, the subjects were interviewed with a short questionnaire to provide information on the completeness of 24-hour urine collection. For each subject a sample of 10 ml from total 24-hour urine was kept in cool box or refrigerator and transport to laboratory and frozen at -20°C for later analysis. Sodium concentration in urine sample was analyzed using ion-selective electrode potentiometry.[9]

Dietary sodium sources assessed by 24-hour direct food weighing[9] during the same 24-hour of urine collection. OMRON digital scale with maximum weight of 2 kg and accuracy at 0.1 g was used. Results were recorded in gram with 1 decimal. During the same 24-hour of urine collection, all foods, condiments added during food preparation, cooking and eaten at the table and left-over foods were weighted to know the exact amount of food eaten by studied subjects within this 24h. Subjects were also asked to provide any foods or drinks that the subjects had consumed out of home for weighing. Recipes of those foods were obtained by interviewing food vendors if material or seasoning contents was unknown.

Anthropometric measurement (body weight and height) was measured by standard methods using calibrated instruments.[10] Height was measured by using wooden height measurement with accuracy at 1 mm. Weight was measured by using SECA electronic scale with accuracy at 100 g. Blood pressure was measured using automatic sphygmomanometer OMRON HEM 762.

Ethical consideration

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the Ethics committee of the National Institute of Nutrition of Vietnam. Written informed consent was obtained from all subjects.

Statistical analysis

Data entry was done using Epidata software version 3.1 and data analysis using SPSS version 15.0. Na intake was obtained by multiplying urinary Na concentration with total volume of 24h urine. Volume of 24-hour urine was corrected by 24 divided by total time of urine collection (ranged from 22–26 hours). Urinary creatinine was used to assess the completeness of 24h urine collection. Subjects with a value for (urinary creatinine [mmol/d] x 113)/(21 x body weight)[11] of less than 0.7 were identified as having incomplete urine[12]. Sodium intake from direct food weighing method was computed using the Vietnam Food composition table (FCT) 2007, which provides sodium content of each food item. For some food items with missing sodium content in the FCT, data from food analysis were used, including some locally processed foods made of pork, beef, liver; salted fish and vegetables and salty sauces and seasoning.

Mean sodium intake was based on mean 24-hour urinary sodium excretion, while sodium sources were assessed by 24-hour direct food weighing. WHO recommends salt intake to be less than 5 g/day or 24-hour urinary sodium excretion to be less than 100 mmol/day or 2 g/day.[13] Dietary sodium sources composed of three groups including condiments added during food preparation, cooking and at the table; natural foods and processed foods. The proportions of sodium content from each group over total dietary sodium intake were reported as mean percentage and SD. Mean difference between two groups was assessed by t-test or Mann-Witney U test. Correlation of sodium intake between two groups was assessed by Pearson or Spearman correlation when appropriate.

RESULTS

General characteristics of study population are presented in Table 4.1. Mean age and BMI were not different between men and women. Men had higher SBP and DBP compared to women, and higher total 24-hour urine volume and 24-hour urinary creatinine concentration.

Mean 24-hour sodium excretion was 188.6 ± 57.5 mmol (4338.4 ± 1322.0 mg) or 10.8 ± 3.3 g salt/ day (Table 4.2). Men tended to have higher mean 24-hour sodium excretion (196.8

Table 4.1 Characteristics of study subjects

	Men		Women	
Number	58		63	
Number by age group (years)				
25–34	15		14	
35–44	14		15	
45–54	15		19	
55–64	14		15	
	Mean	SD	Mean	SD
Age (years)	45.1	10.7	44.8	10.8
Body weight (kg)	55.2	6.2	48.8	6.4
Body height (cm)	162.4	6.5	152.2	5.7
BMI (kg/m^2)	20.9	1.9	21.1	2.5
Systolic blood pressure (mmHg)*	128.9	16.1	122.7	19.5
Diastolic blood pressure (mmHg)*	80.7	11.7	76.5	10.2
24h urine volume (ml/24hour)*	1554.1	472.8	1362.6	428.7
Sodium concentration (mmol/L)	26.4	7.3	27.4	6.8
Creatinine concentration (mmol/L)	5.7	2.2	5.0	1.8

* Mann-Witney U test, p<0.05.

Table 4.2 Sodium (Na) and salt intake assessed by 24-hour urinary sodium excretion in a Vietnamese rural population (n=121)

		24-hour urinary Na excretion (mmol)		24-hour urinary Na excretion (mg)		Salt intake (gram/day)	
	N	Mean	SD	Mean	SD	Mean	SD
Total	121	188.6	57.5	4,338.4	1,322.0	10.8	3.3
Men	58	196.8	56.9	4,526.0	1,357.6	11.3	3.3
Women	63	181.1	57.4	4,165.7	1,320.3	10.4	3.3
Complete urine collection*	75	204.1	56.8	4,694.2	1,306.0	11.7	3.3
Incomplete urine collection*	46	163.4	49.6	3,758.2	1,140.4	9.4	2.9

* Mann-Whitney U test , p<0.001.

± 56.9 mmol) as compared to women (181.1 ± 57.4 mmol, p=0.168). Sixty-two percent of the subjects (75/121) had complete 24-hour urine collection based on urinary creatinine excretion. These subjects had significantly higher mean 24-hour sodium excretion (204.1 ± 56.8 mmol) as compared to subjects with incomplete urine collection (163.4 ± 49.6 mmol, p<0.05).

Figure 4.1 shows that 97.5% of all subjects had an estimated salt intake higher than the WHO's recommendation of less than 5 g/day, among whom 100% of the men and 95.2% of the women. The percentage of subjects who had salt intake at least twice as high as the WHO's recommendation was 58.7% (65.5% in men and 52.4% in women). All subjects with complete urine collection had a salt intake of more than 5 g/day (Figure 4.1). Among subjects with complete urine collection, 73.3% men and 68.8% women had salt intake at 10 g/day or higher.

Table 4.3 shows that sodium in condiments added during cooking or eating at the table accounted for 81% of dietary sodium intake. The other sources were processed food, which contributed 11.6%, and natural foods, contributing 7.4%. Regarding condiments, the largest source was the mixed seasoning ('bot canh', 35.1% of total); 31.6% of total dietary sodium was provided by fish sauce, 7.4% by MSG and 6.1% by table salt. Among the processed foods the largest contribution was from instant noodles (7.8%), followed by salted vegetables (1.4%). Dietary sodium from all other sources besides condiments and processed food only accounted for 11.6% of sodium intake. Sodium intakes obtained by direct food weighing method and 24h-urinary excretion method were significantly correlated (Spearman correlation r=.289, p<0.001).

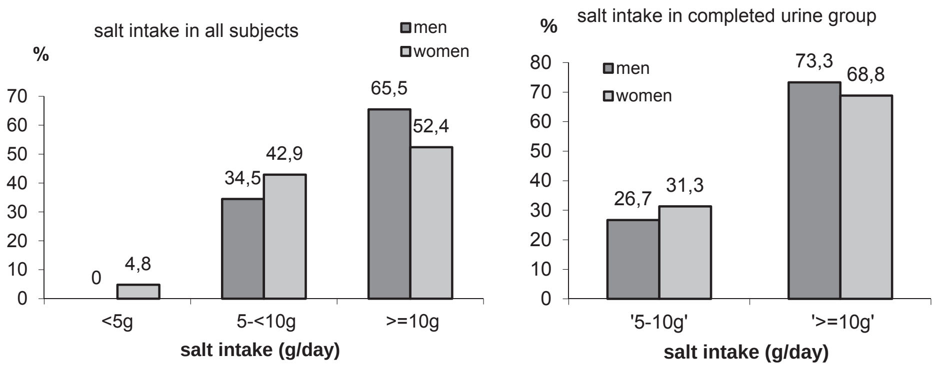

Figure 4.1 Distribution of salt intake by sex in a Vietnamese rural population (n=121).

Table 4.3 Dietary Na source assessed by 24-hour direct food weighing in a Vietnamese rural population (n=121)

Dietary Na sources	Food consumption (g/day) Mean ± SD		Na consumption (mg/day) Mean ± SD		Dietary Na source (%) Mean ± SD	
Condiments added during cooking and at the table						
Mixed seasoning	6.2	5.4	1472.5	1294.6	35.1	21.5
Fish sauce	15.9	13.4	1226.8	1035.6	31.6	23.4
MSG	2.6	3.3	308.3	399.0	7.4	7.7
Pure salt	0.8	2.1	292.2	825.6	6.1	14.8
Soy sauce	0.1	1.1	5.7	63.0	0.2	1.9
Other condiments	0.8	3.4	21.8	122.4	0.6	3.7
Total	26.3	13.9	3327.3	1665.1	81.0	14.0
Processed foods						
Instant noodle	18.1	34.0	470.1	882.1	7.8	14.8
Salted vegetable	11.4	35.7	54.7	160.5	1.4	4.1
Bread	6.1	19.9	8.1	26.6	0.2	0.8
Other processed food	49.6	91.2	77.1	200.8	2.2	6.0
Total	85.2	98.6	610.0	875.1	11.6	15.2
Natural foods	1009.0	283.8	255.7	105.4	7.4	4.1
Grand Total	1120.43	302.84	4192.9	2063.6	100	

DISCUSSION

With an observed mean 24-hour urinary sodium excretion of 188.6 mmol, 196.8 mmol in men and 181.1 mmol in women, our Vietnamese intake was as high as several other countries around the world. Liu et al. reported that mean 24-hour urinary sodium excretion in Chinese adults in different areas ranged from 173.5 mmol to 253.7 mmol.[14] In Japan, mean 24-hour urinary sodium excretion men and women was respectively 221.2 mmol and 194.5 mmol,[15] in US 182.7 mmol and 142.3 mmol,[16] and in Brasil 214 mmol and 186.0 mmol.[17] Across all countries, mean sodium intakes in men were higher than in women, largely reflecting differences in total food consumption.[18]

Salt intake assessed by 24-hour urinary sodium excretion is considered a gold standard method.[5] However the completeness of 24-hour urine collection is an important issue. Methods using urinary creatinine excretion have been commonly used, but all urinary creatinine excretion strategies provide relatively limited information on their efficacy.[12] Therefore, we presented both the urinary sodium excretion of the whole group (including incomplete subjects) and the complete group as assessed by creatinine excretion. The higher urinary sodium excretion of complete urine group suggests that the actual sodium intake in our population is likely to be higher compared to reported above, with a mean 24-hour sodium excretion of 204.1 mmol or salt intake of 11.7 g/day.

The present survey reported that at least 96% of the studied population who had 24-hour urinary sodium excretion greater than the WHO recommended level of 100 mmol. This situation was also observed in the vast majority of people in each of the countries (China, Japan, UK, USA) in the INTERMAP study.[19]

As data from urinary sodium secretion cannot provide information on sodium sources, we used the direct food weighing method for this purpose. The intake of dietary sodium from food weighing provided a lower value (4192.9 mg/day) as compared to the 24-hour urinary sodium excretion (4338.4 mg/day), which agrees with the fact that sodium estimates based on food diaries, weighed records, or 24-hour recall approach tend to underestimate sodium intake as compared with intakes estimated from duplicate diets or 24h urine collections.[8] Our data showed that sodium intake obtained by direct food weighing method and 24h-urinary excretion method was moderately, but significantly, correlated. This confirms that using the direct food weighing method could be used to obtain data on proportion of sodium from different dietary food sources.

Sodium in condiments which were added during cooking or eating at the table accounted for the majority of dietary sodium (81%), which agrees with data from other Asian countries such as China with 75% sodium from salt added in home cooking and 6.4% from soy sauce.[7] In our population, table salt contributed to only 5.9% of dietary sodium, but mixed seasoning ('bot canh', a mix of salt, MSG and some other spices) provided a large proportion of 35.1% of dietary sodium. Fish sauce provided the second largest contribution with 31.6% of sodium intake. Monosodium glutamate (MSG) consumption, which contributed to 7.4% of dietary sodium, was higher as compared to China (0.6%).[7] Soy sauce was not commonly consumed, and accounted for only 0.2% of dietary sodium, which was lower than 20% in Japan and 6.4% in China.[7] These results indicate that in rural population of the Red river delta, like this studied population, reducing high-sodium condiments, particularly mixed seasoning, fish sauce and MSG added during cooking and at the table must be targeted as the first priority in order to reduce sodium consumption.

Instant noodle is a favorite food, particularly for breakfast, because it is a tasty, cheap and convenient fast food. However, among the category processed foods, instant noodles (without seasoning) contributed the largest proportion of 7.8% of dietary sodium, higher as compared to 4.6% (from bread and noodles) in Japan and 2.2% in China.[7] The contribution of sodium from the dish of instant noodles was 12.9% if the amount of condiments which is often added during preparation of instant noodles had been taken into account. The salted vegetables accounted for 1.4% of sodium intake, which was lower than its consumption in Japan (9.8%).7 Promoting less consumption of instant noodle could thus also be a mean to achieve sodium intake reduction.

Since the physiological need of sodium is around 8–10 mmol (184–230 mg) sodium/day,[5] sole intake of dietary sodium from natural foods, providing about 256mg sodium/day in our study, would meet this requirement. Therefore, under acclimatized environment, consumption of only natural foods could provide enough sodium for body functions. In these conditions, it may be reasonable to recommend not adding or consuming any sodium-containing condiments during food preparation, cooking and eating.

Limitations of this study were that data collected on a small sample size in one commune and only single 24-hour urine sample and food weighing data had been collected. However, with well-trained data collectors and standardized protocols for urine collection and dietary assessment, findings from this rural commune are indicative of sodium intake and dietary sodium sources for the larger rural population, which comprises of about 75–80% of the population, in the northern part of Vietnam. To the best of our knowledge this is the first report on sodium excretion and dietary sources in this country.

In conclusion, excessive sodium intake did exist in most of the studied population. Reducing sodium intake and particularly limiting condiments added during cooking and at the table (81% of total sodium intake) should be given priority in efforts of sodium restriction for the control and prevention of hypertension and related chronic diseases in Vietnam.

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manuscript. The authors declared to have no conflict of interests. This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the Ethics committee of the National Institute of Nutrition, Vietnam.

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Chapter 5

Sodium-reduced and potassium-enriched condiments reduce sodium intake and blood pressure in Vietnamese adults: a randomized controlled trial

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ABSTRACT

Reducing salt intake lowers blood pressure (BP), a major risk factor for cardiovascular diseases, but few studies have investigated whether this is an effective measure in the context of Asian developing countries. This study aims to investigate the effects of sodium-reduced and potassium-enriched condiments on sodium intake and BP in untreated (pre)hypertensive Vietnamese adults in a rural community, using a randomized double-blind placebo-controlled trial. A total of 173 men and women between 45 and 64 years of age with untreated elevated BP (systolic BP 130–160 mmHg or diastolic BP 85-100 mmHg) and free of diagnosed cardiovascular or kidney disease were randomized into the intervention group receiving sodium-reduced and potassium-enriched condiments (salt and 'bot canh') and the control group receiving regular condiments for home food preparation and dining for a period of 8 weeks. Iodine content was similar in all products at a recommended level of 20 ppm. The average blood pressure was ~140/82 mmHg and the average daily salt intake was ~11 g/d (191 mmol/ 24-hour sodium) at baseline. During intervention, the median 24-hour sodium excretion decreased by 52.3 mmol in the intervention group and by 23.8 mmol in the control group, a net difference of 28.5 mmol (1.6 g/d salt). The mean change in BP in the intervention compared to the control group was -2.6 mmHg (95% CI -4.6 to -0.5, p=0.013) for systolic BP and -1.6 mmHg (95% CI -3.0 to -0.2, p=0.024) for diastolic BP. The prevalence of iodine deficiency significantly reduced in both groups (from 72% to 36% in controls, from 66% to 41% in intervention group). In conclusion, replacing regular salt and 'bot canh' with sodium-reduced and potassium-enriched condiments could make a relevant contribution to lowering BP in (pre)hypertensive Vietnamese adults. Salt iodization should be reconsidered to ensure iodine intake of the population. This study has ClinicalTrials.gov identifier of NCT02016404.

INTRODUCTION

Hypertension is highly prevalent worldwide. It has been estimated that 26.4% of the adult population had hypertension in 2000 and this would increase to 29.2% by 2025.[1] Accordingly the total number of adults with hypertension in 2000 was 972 million The number of adults with hypertension in 2025 was predicted to increase by about 60% to a total of 1.56 billion.[1] High blood pressure accounts for 62% of strokes and 49% of cardiovascular diseases (CVDs).[2] Worldwide, 7.6 million premature deaths (about 13.5% of the global total) and 92 million DALYs (6.0% of the global total) were attributed to high blood pressure (BP) in 2001.[3] Overall, about 80% of the attributable burden occurred in low-income and middle-income economies.[3] Vietnam, a developing Asian country, is now facing an increasing burden of hypertension and related CVDs. The World Health Organization (WHO) reported that 33% of the Vietnamese adults aged 25 years and older were hypertensive in 2008.[4]

Diets that are high in sodium adversely affect BP and could have harmful effects on CVDs, including left ventricular hypertrophy and stroke, and renal disease.[2] The Cochrane meta-analysis of randomized salt reduction trials by He et al. showed that the mean change in urinary sodium (reduced salt vs. usual salt) was -75 mmol/24-hour (equivalent to a reduction of 4.4 g/day salt) and with this reduction in salt intake, the mean BP change was -4.18 mm Hg for systolic BP and -2.06 mm Hg for diastolic BP.[5] As recommended by WHO, salt reduction strategies are the most cost-effective intervention and currently being implemented in many countries for the prevention of hypertension and related CVDs.[6] In addition to reducing sodium intake, an increase in potassium intake could make an important contribution to the prevention of hypertension, especially in populations with elevated BP.[7] The combination of reduced sodium and increased potassium intake by replacing regular salt with sodium-reduced and potassium-enriched salt may have larger BP effects than sodium or potassium alone.[8-11] The switch from regular salt to potassium-enriched salt in a group of elderly veterans resulted in a 40 percent reduction in CVD mortality and 0.3–0.9 years longer life.[12]

High sodium condiments added during food preparation, cooking or at the table accounts for the majority (63–83%) of dietary sodium intake in Asia.[13] In Vietnam we recently conducted a survey in a rural community and found that the mean urinary sodium excretion was 189 ± 58 mmol/ day or 10.8 ± 3.3 g salt/ day, which is more than twice the WHO recommended maximum level of 5 g/day. Urinary potassium excretion was 34 ±

13 mmol/ day (1723 ± 516 mg/day), which is lower than the WHO recommendation of 90 mmol/ day (3510 mg/day).[14] Dietary sodium in condiments added during cooking or eating at the table accounted for 81% of dietary sodium, and was provided by 'bot canh', a traditional condiment based on salt, pepper, monosodium glutamate (MSG) and herbs (35.1%); fish sauce (31.6%); MSG (7.4%) and pure salt (6.1%). Therefore, replacing regular condiments with sodium-reduced and potassium-enriched condiments may have potential to reduce sodium intake and BP in Vietnam.

We conducted a randomized double-blind placebo controlled trial to investigate the effects of sodium-reduced and potassium-enriched condiments ('bot canh' and salt) on BP in untreated prehypertensive and hypertensive adults. In addition, we also investigated the change in iodine excretion among the treatment groups as both the regular and sodium-reduced and potassium-enriched salt and bot canh were iodized at the recommended level of 20 ppm.[15]

MATERIALS AND METHODS

Subjects

A total of 1251 men and women between 45 and 64 years of age from a general population in a rural community of Thanh Oai district, Hanoi, Vietnam, were screened for elevated BP. The study was conducted between June and September 2013. Subjects (n=180, see Figure 5.1) with untreated prehypertension to mild hypertension (systolic BP between 130 and 160 mmHg and/or diastolic BP between 85 and 100 mmHg) based on the mean of measurements during two visits one week apart, were invited to participate in the trial. To be eligible for the trial, the subjects had no known diagnosed or self-reported CVD or kidney diseases. The run-in period of one week before randomization was conducted with distribution of regular 'bot canh' and salt to identify subjects unlikely to comply with the treatment and follow-up process. All subjects accepted to proceed to the trial. The study was approved by the Ethical committee of the National Institute of Nutrition, Vietnam Ministry of Health. All participants provided informed consent prior to the data collection.

Treatment allocation to control or intervention group was done using block randomization with random block-size using a computerized randomization table.[16] Subjects and health care providers were unaware of group that the subjects were assigned to. During the

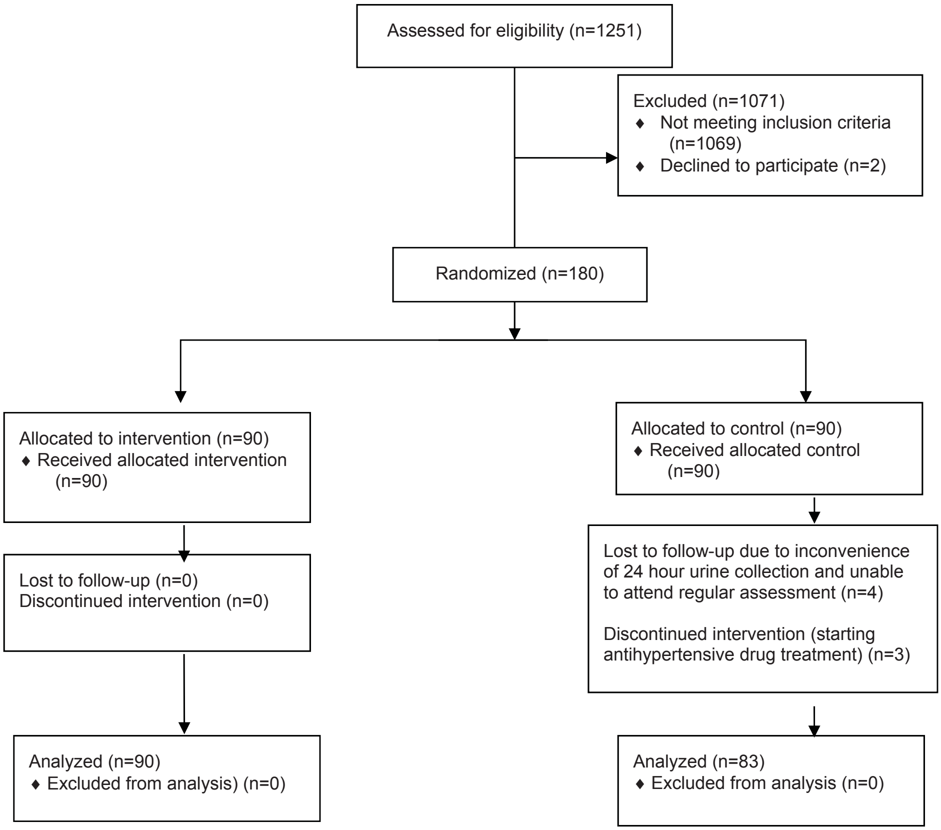

Figure 5.1 Flow chart of research design.

baseline survey, 4 subjects withdrew because of the inconvenience related to 24h urine collection. In the first trial week, another 3 subjects were excluded because antihypertensive medication was prescribed by their general practitioners. The remaining 173 subjects (83 control and 90 intervention subjects) who completed the trial (Figure 5.1) were included in data-analysis.

5

Intervention

During 8 weeks of intervention, the intervention group received iodized sodium-reduced and potassium-enriched condiments ('bot canh', a traditional mixture of salt (80.5%), MSG (7.5%), sugar (6.7%) and herbs (5.3%)) and iodized sodium-reduced and potassium-enriched salt for home food preparation, cooking and eating at the table. The control group received regular iodized 'bot canh' and salt. Sodium-reduced and potassium-enriched condiments and regular condiments were packed in similar packages of the same weight (except small letter A or B place on the label) so that the cooks, health-care providers and subjects did not recognize the type of condiments. Sodium-reduced and potassium-enriched and regular bot canh and salt were experimentally produced for this trial at the National Institute of Nutrition of Vietnam.

The ratio of Na/K (by weight) in the Sodium-reduced and potassium-enriched salt was 33/67 and in the low sodium 'bot canh' 40/60, thus the sodium-reduced and potassium-enriched products had 67% (salt) and 60% ('bot canh') less Na as compared to regular products. Iodine content was similar in regular and sodium-reduced and potassium-enriched salt and bot canh at a level of 20 ppm as recommended.[15]

The subjects were instructed to consume only the provided bot canh and salt, and to avoid other high sodium condiments such as fish sauce, soy sauce, shrimp sauce and MSG. They were instructed to record all type of condiments they consumed, their health complaints and drugs they had taken, if any, and handed this in to the project staff every two weeks. During the intervention, a dietitian visited the subjects at their home to make sure they use studied condiments in food preparation, cooking and at the table and eat at least two homemade meals every day. Subjects and research staff involved in the study were unaware of what type of condiments the subjects used during the intervention.

Measurements

BP, pulse rate, body weight, body height and waist circumference were assessed at baseline and during the 8-week follow-up period using the standard protocol of the WHO STEPS guideline.[17] Additionally, BP was measured after 2, 4 and 6 weeks of intervention. BP was measured using digital automatic BP monitor (OMRON HEM-762) with subjects in sitting position, with appropriate size cuff on the left arm and the cuff at the heart level. At each visit, after at least 15 minutes rest, three measurements of BPs were taken with 3-minute intervals. When the last two measurements differed by more than 10 mm Hg an additional measurement was taken and the outlying measurement was omitted. To obtain stable estimates, baseline BP was taken as the average of at least two out of three visits before the start of the intervention, i.e. visits for screening, one week thereafter and at baseline, each one week apart.

24-hour urine collection was carried out at baseline and after 8 weeks of intervention. Start time, end time and total 24-hour-urine volume were recorded. At the end of the 24-hour urine collection, the subjects were interviewed with a short questionnaire to provide information on the completeness of 24-hour urine collection. Urine samples were analyzed for sodium, potassium and calcium by ion-selective electrode potentiometry (Analyzer ISE 5000), creatinine and albumin by spectrometry method using auto-analyzer (Beckman Coulter, AU 480) and iodine by Camspec M107 Spectrophotometer. The completeness of 24-hour urine collection was assessed by urinary creatinine excretion, using the following formula: urinary creatinine [mmol/d] x 113)/(21 x body weight).[18] Subjects with a value <0.7 were identified as having incomplete urine.[19]

Data analysis

Data were analyzed using SPSS statistics 20. BP and electrolyte excretion were expressed as means with standard deviation. Changes in electrolyte excretion after 8 week of intervention from baseline were compared between the intervention group and the control group using independent t-test or Mann Whitney U test for two independent variables when the variables were skewed. The mean BP during intervention was the average of 4 measurements of week 2, 4, 6, and 8.

The sample size of this study (173 subjects) was large enough to detect a difference in sodium excretion of 44 mmol/day and BP of 3.0 mmHg systolic and 1.8 mmHg diastolic with the power of 80%, SD of 8.5 mmHg for change in SBP and 4.5 mmHg for change in DBP,[20] and a two sided p-value of 0.05.

RESULTS

Characteristics of 173 subjects who completed the study are shown in Table 5.1. About half of the subjects were female and the mean age was 56 years. Mean sodium excretion at baseline was 191 ± 96 mmol/24-hour, indicating a daily salt intake of 11 ± 5.5 grams, and mean potassium excretion was 45.6 ± 18.5 mmol/24-hour. Baseline BP was ~140/82 mmHg. There were no significant differences in age, sex, BMI, diastolic BP, heart rate and urinary parameters between the intervention and control group. Baseline systolic BP was 2.2 mmHg higher in the intervention than the control group, which was statistically significant (p=0.02).

Table 5.1 Baseline characteristics of 173 (pre)hypertensive Vietnamese adults who participated in a sodium reduction trial, by treatment group

	Control (n=83)		Low-sodium intervention (n=90)	
Number of women	48	(58%)	45	(50%)
Age (year)	55.5	± 5.6	56.4	± 5.1
SBP (mmHg)*	138.7	± 7.2	140.9	± 6.9
DBP (mmHg)	80.9	± 6.3	82.6	± 7.0
Pulse rate(beats/min)	81.9	± 10.7	80.1	± 12.3
Body weight (kg)	54.4	± 8.7	55.0	± 7.9
Body height (m)	156.2	± 7.6	155.9	± 7.2
BMI (kg/m^2)	22.2	± 3.0	22.5	± 2.6
Waist circumference (cm)	79.8	± 7.7	80.6	± 6.7
Urinary parameters				
Sodium (mmol/24h)	192.3	± 96.5	190.6	± 94.5
Potassium (mmol/24h)	44.9	± 17.4	46.2	± 19.6
Calcium (mmol/24h)	4.6	(4.2)	4.7	(4.3)
Creatinine (mmol/24h)	10.3	± 3.0	10.7	± 3.2
Albumin (mg/24h)	1.04	(1.02)	1.14	(1.39)
Iodine (µg/24h)	83.9	(72.0)	80.6	(88.3)

Values are means ± SD or median (interquartile range) in case of skewed distribution.
*P-value = 0.02 for difference between control and intervention group; all other comparisons were not statistically significant.

Effects on sodium and potassium excretion

The changes in urinary electrolyte excretion in the intervention and control groups are presented in Table 5.2 for subjects with complete 24-hour urine collection both at baseline and follow-up (n=148). The data analysis with all subjects (including those did not complete 24-hour urine collection) showed similar results (Supplemental Table S5.1). During the intervention, the reduction of 24-hour sodium excretion was significantly larger in the intervention group compared to the control group (-52.3 mmol vs. -23.8 mmol, p=0.035), with a net difference of -28.5 mmol (95% CI -55.1 to -2.1), which corresponds to -1.6 g difference in daily salt intake (95% CI -3.2 to -1.2). The 24-hour urinary potassium excretion after 8 weeks of intervention was significantly reduced in both groups. The reduction was smaller in the intervention group as compared to the control group (6.5 ± 20.6 mmol/d vs 11.3 ± 19.5 mmol/d, p=0.06) with a non-significant net difference of +4.7 mmol/d (95% CI -0.4 to 9.8), which equals +183 mg/d.

The urinary sodium-to-potassium (Na/K) ratio increased from 4.5 to 5.0 in the control group and decreased from 4.4 to 3.6 in the intervention group, and the difference of -1.2 (95% CI -2.0 to -0.5) units was significantly different between the treatment groups (p=0.001).

Table 5.2 24-hour excretion of sodium, potassium and other parameters in 148 participants with completed urine collections, by treatment group

	Control (n=75)		Low-sodium intervention (n=73)		P-value *
Sodium (mmol/24h)					
Baseline	193.9	± 99.3	193.8	± 87.6	0.71
Follow up	170.1	± 81.0	141.5	± 64.9	0.023
Change	-23.8	± 126.1	-52.3	± 88.2	0.035
P-value**	0.17		<0.001		
Difference (mean, 95% CI)	-28.5 (-55.1 to -2.1)				
Salt intake (g/d)					
Baseline	11.1	±5.7	11.1	±5.0	0.71
Follow up	9.8	±4.7	8.1	±3.7	0.023
Change	-1.4	±7.2	-3.0	±5.1	0.035
P-value**	0.17		<0.001		
Difference (mean, 95% CI)	-1.6 (-3.2 to -1.2)				
Potassium (mmol/24h)					
Baseline	45.8	±17.8	46.8	±20.2	0.96
Follow up	34.6	±13.5	40.2	±14.7	0.006
Change	-11.3	±19.5	-6.5	±20.6	0.06
P-value**	<0.001		0.002		
Difference (mean, 95% CI)	4.7 (-0.4 to 9.8)				
Na/K ratio					
Baseline	4.5	± 2.1	4.4	± 1.8	0.73
Follow up	5.0	± 1.8	3.6	± 1.4	<0.001
Change	0.5	± 2.6	-0.7	± 2.1	0.001
P-value**	0.04		0.004		
Difference (mean, 95% CI)	-1.2 (-2.0 to -0.5)				
Calcium (mmol/24h)					
Baseline	5.3	±3.0	5.1	±2.9	0.81
Follow up	4.6	±2.5	4.0	±2.2	0.09
Change	-0.6	±3.1	-1.1	±2.9	0.23
P-value**	0.05		<0.001		
Difference (mean, 95% CI)	-0.5 (-1.5 to 0.5)				
Albumin (mmol/24h)					
Baseline	4.3	± 14.5	6.0	± 12.5	0.67
Follow up	8.8	± 24.2	6.7	± 16.6	0.67
Change	4.6	± 19.7	0.7	± 12.2	0.87
P-value**	0.69		0.62		
Difference (mean, 95% CI)	-3.9 (-9.2 to 1.5)				
Creatinine (mmol/24 h)					
Baseline	10.5	± 3.0	11.2	± 3.2	0.42
Follow up	11.1	± 3.9	11.2	± 3.5	0.94
Change	0.6	± 3.3	-0.1	± 3.7	0.25
P-value**	0.28		0.60		
Difference (mean, 95% CI)	-0.6 (-1.8 to 0.5)				

Table 5.2 continues on next page

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Table 5.2 *Continued*

	Control (n=75)		Low-sodium intervention (n=73)		P-value *
Iodine (µg/24h)					
Baseline	104.8	± 71.2	103.6	± 78.3	0.49
Follow up	155.4	± 96.5	138.4	± 84.3	0.28
Change	50.6	±102.1	34.8	± 95.5	0.47
P-value**	<0.001		<0.001		
Difference (mean, 95% CI)	-15.8 (-47.9 to 16.3)				
Iodine deficiency (%) (<100 µg/L)					
Baseline	72.0		65.8		0.26
Follow up	36.0		41.1		0.32
P-value***	<0.001		0.002		

*P-value from Mann-Whitney U test.
**P-value from Wilcoxon signed rank test.
***P-value from McNemar test.

Effects on BP

The changes in BP during the intervention are presented in Figure 5.2. During intervention, systolic BP decreased on average by 7.8 mmHg in the intervention group, and by 5.2 mmHg in the control group, resulting in a net difference of -2.6 mmHg (95% CI -4.6 to -0.5, p=0.013). For diastolic BP the net difference in reductions during the intervention period was of -1.6 mmHg (95% CI -3.0 to -0.2, p=0.024). The intervention had not significant effect on heart rate and BMI (Table 5.3).

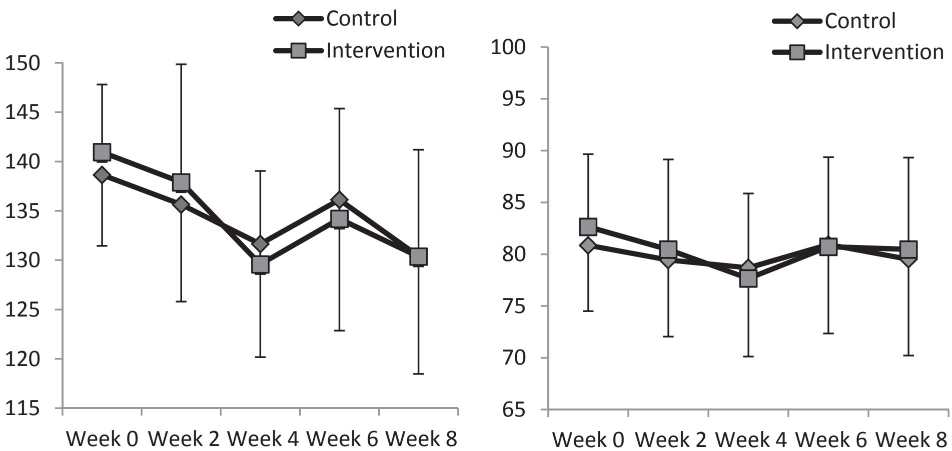

Figure 5.2 Changes in SBP and DBP during the study period by treatment group.

Table 5.3 Changes of systolic and diastolic BP during intervention by treatment groups

	Baseline	Week 2	Week 4	Week 6	Week 8	Intervention mean*	Treatment effect**
Systolic BP (mmHg)							
Control	138.7 ± 7.2	135.6 ± 9.8	131.6 ± 11.5	136.1 ± 13.3	130.4 ± 11.9	133.4 ± 9.1	-5.2 ± 6.8
Intervention	140.9 ± 6.9	137.9 ± 12	129.6 ± 9.5	134.2 ± 11.2	130.4 ± 10.8	133.2 ± 8.4	-7.8 ± 6.6
Difference#	2.3 (0.2 to 4.4)	2.3 (-1.1 to 5.6)	-2.1 (-5.2 to 1.1)	-1.9 (-5.7 to 1.8)	0.0 (-3.4 to 3.4)	0.3 (-2.4 to 2.9)	-2.6 (-4.6 to -0.5)
P-value	0.033	0.19	0.21	0.31	0.99	0.84	0.013
Diastolic BP (mmHg)							
Control	80.9 ± 6.3	79.4 ± 7.4	78.7 ± 8.6	80.9 ±8.6	79.5 ± 9.3	79.7 ± 7.3	-1.2 ± 4.5
Intervention	82.6 ± 7.0	80.5 ± 8.7	77.7 ± 8.2	80.7 ± 8.7	80.5 ± 8.9	79.9 ± 7.2	-2.8 ± 4.6
Difference	1.8 (-0.2 to 3.8)	1.0 (-1.5 to 3.5)	-1.0 (-3.6 to 1.1)	-0.2 (-2.9 to 2.5)	0.9 (-1.8 to 3.7)	-0.2 (-2.4 to 2.0)	-1.6 (-3.0 to -0.2)
P-value	0.08	0.42	0.43	0.88	0.49	0.86	0.024
Heart rate (bpm)							
Control	81.9 ± 10.7				80.5 ± 10.2		-1.5 ± 10.3
Intervention	80.1 ± 12.3				80.8 ± 11.0		0.6 ± 9.1
Difference	-1.7 (-5.2 to 1.7)				0.3 (-2.9 to 3.5)		2.1 (-0.3 to 5.0)
P-value	0.32				0.85		0.14
Body weight (kg)							
Control	54.4 ± 8.7				54.2 ± 8.9		-0.2 ± 1.6
Intervention	55.0 ± 7.9				55.1 ± 8.0		0.1 ± 1.3
Difference	0.6 (-1.9 to 3.2)				0.89 (-1.6 to 3.4)		0.24 (-0.2 to 0.7)
P-value	0.61				0.48		0.27

*Mean of measurements during intervention period (week 2 through 8).
**Difference in change from baseline between the groups.
.#Difference between the low-sodium intervention and control group, with 95% CI.

Other treatment effects

Treatment did not affect urinary calcium excretion in the intervention compared to the control group (-1.1 mmol/day vs. -0.6 mmol/day, p=0.23). There were also no effects on urinary albumin and creatinine excretion. Urinary iodine increased in both the control and intervention group by 50.6 mmol/24h and 34.8 mmol/24-hour, respectively, but this difference between the groups was not statistically significant (Table 5.2).

Urinary iodine excretion was not different between the treatment groups at baseline and after 8 weeks of intervention; a significant increase was observed in both groups (+50.6 µmol/24h and +34.8 µmol/24-hour) (Table 5.2). The prevalence of iodine deficiency, as defined as urinary iodine concentration below 100 µg/L, was significantly reduced in both groups, from 72% to 36% ($p<0.001$) in the control group and from 66% to 41% (p=0.002) in the intervention group.

DISCUSSION

This study is the first randomized double blind controlled trial on reduced sodium intake and BP in Vietnam. We demonstrated that the use of low-sodium and high-potassium salt and condiment ('bot canh') for 8 weeks reduces salt intake on average by 1.6 g/day and BP by 2.6/1.6 mmHg.

The baseline salt intake of our study population (~11 g/d) was consistent with the estimated salt intake of 10.8 g/d in a survey in this community in 2010 (manuscript submitted). When considering the sodium lost via feces and sweat, the actual intake is about 12 g/d.[21] Probably, due to increased awareness, a reduction in sodium intake was observed also in the control group in this study. However, the intervention group that used a sodium-reduced and potassium-enriched salt and 'bot canh' had a significantly 1.6 g/d larger reduction in salt intake as compared to the control group. Similar changes in sodium intake were observed in other trials of low-sodium, high potassium condiments or foods conducted in the Netherlands (1.6 g/day),[9] and Japan (1.4 g/day).[11]

The 24h urinary potassium excretion also declined in both groups, but less in the intervention than in the control group. This reduction might due to the potassium loss in sweat caused by high temperatures, especially for those who had hard work during the harvest days at the follow-up survey. Note that potassium intake, as based on potassium excretion and taking into account that about 77% is excreted in urine,[21] was ~2300 mg/d which is much less than the WHO recommended level of 3510 mg/d.[14]

Our findings are in line with previous trials of sodium reduction and potassium supplementation in subjects with elevated BP. A review of 40 sodium trials and 27 potassium trials in adults by Geleijnse et al indicated that a sodium reduction of -77 mmol/d was associated with a change of -5.2 mmHg systolic BP and -3.9 mmHg diastolic BP in the hypertensives.[7] He et al. (2013) reviewed 34 randomized trials and showed that a mean change in urinary sodium (reduced low sodium salt vs. usual salt) of -75 mmol/24 hour (equivalent to a reduction of 4.4 g/day salt) and a change in BP of -5.4 mm Hg for systolic BP and -2.8 mm Hg for diastolic BP.[5]

There are two reported studies using low sodium seasonings in Asia. One double-blind randomized placebo controlled trial evaluated the feasibility of the 6 week-use of low sodium soy sauce and miso, 25% and 20% lower in sodium content than common soy sauce and miso, in 64 Japanese subjects. A salt reduction of 1.4 g/day was achieved, but overall no significant reduction in BP was found, except for a diastolic BP reduction of 6.4 mmHg in those aged 40 years and older.[11] Another randomized trial using a salt substitute (65% sodium chloride, 25% potassium chloride, 10% magnesium sulphate) for 12 months reported no change in sodium excretion but higher potassium excretion by rural Chinese adults at high risk of CVDs. The overall difference in systolic BP was -3.7 mmHg, with no detectable effect on diastolic BP.[10]

A modest reduction in population salt intake worldwide will result in a major improvement in public health.[22] It has been estimated that a reduction in dietary intake of sodium of 50 mmol/day would reduce the number of people needing antihypertensive therapy by 50%, the number of deaths from strokes by 22% and the number of deaths from CHD by 16%.[6] Therefore, in a population with about 80% of dietary sodium intake from high sodium seasonings added during food preparation, cooking and at the table, such as in Vietnam, the use of sodium-reduced and potassium enriched salt and bot canh may be a valuable and cost-effective strategy in the prevention of hypertension and CVD.

In parallel with sodium reduction efforts to prevent hypertension and CVD, the iodine content in salt and other seasonings has to be taken into account when salt reduction is conducted. In the present study, despite the observed reduction in salt intake, 24-hour urinary iodine excretions were increased in both study groups and hence the prevalence of iodine deficiency in the study population was significantly reduced. This was due to the iodine content in our experimental products, both regular and low sodium, which contained the recommended level of 20–40 ppm.[15] Currently, salt iodization is not mandatory in

Vietnam, therefore in parallel with iodized salt there is also non-iodized salt available on the market. In addition to iodized salt, iodized bot canh is available in the market on voluntary basis, but all other salty condiments are not iodized. Our finding suggests that the current salt and seasoning commonly consumed by this population do not ensure sufficient iodine intake. A higher iodine content for salt and bot canh is recommended or iodization should also be applied to other condiments or other food vehicles.

A limitation of this study was the 2-mmHg difference in baseline BP between the study groups. This difference was caused by the drop-out of 7 subjects in the control group during the baseline survey and the first week of intervention. When analyzing all randomized subjects, including the 7 drop-outs, there were no significant differences in baseline BP between the intervention and control group (140.9 vs 139.5 mmHg systolic, p=0.07; 82.6 vs. 81.4 mmHg diastolic, p=0.25). Regrettably, we had no follow-up BP data for subjects who dropped out, and therefore no intention-to-treat analysis was performed. Three out of the 7 dropout subjects in the control group left the study due to initiation of antihypertensive drug treatment and had high baseline BPs (mean systolic BP 159.3 ± 0.9 mmHg, mean diastolic BP 97.0 ± 1.7 mmHg). If these subjects had completed the study, the mean BPs of the control group would have been higher and the larger net BP reduction could have been observed. However, our study has its strength of a well-controlled trial and highly motivated participants. The low-sodium salt and bot canh were easily accepted by the study subjects and their family members, and compliance was excellent. Actually, the subjects expressed their preference for low sodium products as compared to the commonly consumed condiments.

In conclusion, using sodium-reduced and potassium-enriched salt and 'bot canh' could be an effective approach for lowering salt intake and BP in prehypertensive and mildly hypertensive adults in Vietnam. Salt iodization should be reconsidered to ensure iodine intake of the population.

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Supplemental Table S5.1 Mean (SD) 24-hour excretion of sodium, potassium and other parameters in 173 trial participants by treatment group

	Control (n=83*)	Intervention (n=90*)	P-value*
Sodium (mmol/d)			
Baseline	192.3 ± 96.5	190.6 ± 94.5	0.97
Follow up	164.4 ± 80.6	136.9 ± 62.0	0.02
Change	-27.8 ± 121.6	-53.7 ± 91.6	0.06
P-value**	0.044	0.000	
Salt intake (g/d)			
Baseline	11.1 ± 5.6	11.0 ± 5.4	0.97
Follow up	9.5 ± 4.6	7.9 ± 3. 6	0.02
Change	-1.6 ± 7.0	-3.1 ± 5.3	0.06
P-value**	0.044	<0.001	
Potassium (mmol/d)			
Baseline	44.9 ± 17.4	46.2 ± 19.6	0.82
Follow up	35.5 ± 13.4	39.3 ± 14.4	0.002
Change	-11.4 ± 18.7	-7.0 ± 20.5	0.06
P-value**	0.000	0.000	
Na/K ratio			
Baseline	4.5 ± 2.0	4.3 ± 1.9	0.41
Follow up	5.0 ± 1.8	3.6 ± 1.4	<0.001
Change	0.5 ± 2.6	-0. ± 2.1	0.001
P-value**	0.06	0.004	
Calcium (mmol/d)			
Baseline	5.2 ± 3.1	6.0 ± 9.0	0.84
Follow up	4.6 ± 2.6	3.9 ± 2.2	0.075
Change	-0.6 ± 3.3	-2.1 ± 9.3	0.20
P-value**	0.032	<0.001	
Albumin (mmol/d)			
Baseline	4.3 ± 14.2	8.0 ± 26.6	0.55
Follow up	8.2 ± 23.1	8.4 ± 21.7	0.46
Change	3.8 ± 19.1	0.4 ± 13.6	0.59
P-value**	0.85	0.24	
Creatinine (mmol/d)			
Baseline	10.3 ± 3.0	10.7 ± 3.2	0.43
Follow up	10.6 ± 4.0	10.5 ± 3.6	0.95
Change	0.3 ± 3.3	-0.2 ± 3.8	0.29
P-value**	0.85	0.30	
Iodine (µg/d)			
Baseline	104.6 ± 70.0	101.2 ± 74.4	0.41
Follow up	151.5 ± 95.8	133.2 ± 79.2	0.23
Change	47.0 ± 100.2	32.0 ± 87.5	0.37
P-value**	<0.001	<0.001	

Supplemental Table S5.1 continues on next page

Supplemental Table S5.1 ***Continued***

	Control (n=83[×])	Intervention (n=90[××])	P-value*
% Iodine deficiency (<100 μg/L)			
Baseline	69.9	64.4	
Follow up	37.3	35.6	
P-value**	<0.001	0.002	

*P-value for Independent-samples Mann Whitney U test (the control vs. the intervention).
**P-value for Mc Nemar test (baseline vs. follow-up).
[×]8/83 subjects with incomplete urine collection.
[××]17/90 subjects with incomplete urine collection.

Chapter 6

General discussion

This thesis addresses the public health problem of hypertension in Vietnam, with studies on prevalence, determinants, particularly overweight and obesity trend, alcohol use, physical activity, area of residence, age, education level, salt intake and its dietary sources, and an intervention to reduce salt intake for lowering BP among adults.

In the present chapter we first give an overview of the main findings, followed by a discussion of methodological aspects, public health implications and future research directions.

MAIN FINDINGS

Hypertension was prevalent among Vietnamese adults (***Chapter 2***). Using data of National Adult Overweight Survey from 2005 we showed that the national prevalence of hypertension was 20.7% (95% CI 19.4–2.1), and the prevalence of prehypertension 41.8% (95% CI 40.4–43.1). Hypertension and prehypertension were more prevalent among men than among women. Higher age, overweight, alcohol consumption (among men), and living in rural areas (among women) were independently associated with a higher prevalence of hypertension, whereas higher physical activity and education level were inversely associated. Age, BMI, and living in rural areas were independently associated with an increased prevalence of prehypertension. Hypertension awareness, treatment and control were very low in Vietnam. Among the hypertensive population, 25.9% were aware of having hypertension, 12.2% were treated. Among the treated hypertensive patients, 32.4% had their BP controlled (***Chapter 2***).

The burden of hypertension will increase when the rapid increase in overweight and obesity continues. The distribution of BMI across the population and population groups indicated a shift towards higher BMI levels in 2005 as compared to 2000 (***Chapter 3***). The nationwide prevalence of overweight (BMI ≥25 kg/m^2) and obesity (BMI ≥30 kg/m^2) was 6.6% and 0.4%, respectively in 2005, almost twice the rates of 2000 (3.5% and 0.2%). Using the Asian BMI cut-off of 23 kg/m^2 the overweight prevalence was 16.3% in 2005 and 11.7% in 2000. In contrast, the underweight prevalence (BMI <18.5 kg/m^2) of 20.9% in 2005 was lower than the rate of 25.0% in 2000. The prevalences of underweight and overweight were both higher in women than in men in 2000 and 2005. Urban residents were more likely to be overweight and less likely to be underweight as compared to rural residents in both years. The shifts from underweight to overweight were more clear among those with higher food expenditure levels (***Chapter 3***).

In a rural population near Hanoi, the mean 24h-sodium excretion was 188.6 ± 57.5 mmol (4.3 g) and salt equivalent urinary excretion was 10.8 ± 3.3 g/day (***Chapter 4***). Men had higher mean 24h-sodium excretion (196.8 ± 56.9 mmol or 4.5 g) as compared to women (181.1 ± 57.4 mmol or 4.2 g); 97.5% of the men and women had a salt intake higher than the WHO recommendation of <5 g/day. Sodium in condiments added during cooking or eating at the table accounted for 81% of the sodium intake. Processed foods contributed 11.6% and natural foods 7.4%. Regarding the condiments, the largest source was the mixed seasoning ('bot canh', 35.1% of total); 31.6% of total dietary sodium was provided by fish sauce, 7.4% by MSG and 6.1% by table salt (***Chapter 4***).

In ***Chapter 5*** it was shown that eight-week consumption of low-sodium high-potassium substitutes (salt and 'bot canh') caused a net decrease in median 24-hour sodium excretion of 28.5 mmol (1.6 g salt). The mean change in BP in the intervention compared to the control group was -2.6 mm Hg (95% CI -4.6 to -0.5, p=0.013) for systolic BP and -1.6 mmHg (95% CI -3.0 to -0.2, p=0.024) for diastolic BP. The salt and 'bot canh' provided to the intervention and control group contained the recommended amount of 20–40 ppm of iodine, which significantly reduced the prevalence of iodine deficiency in both groups (from 72% to 36% in the control group and from 66% to 41% in the intervention group).

These findings highlight the need for effective prevention strategies and actions for hypertension and overweight and obesity in Vietnam, and suggest a potential approach to reduce the population's salt intake by using condiment reformulation.

METHODOLOGICAL ASPECTS

Representativeness

The data used in ***Chapter 2*** and ***Chapter 3*** were from the 2005 National Adult Overweight Survey (NAOS 2005) and the 2000 National Nutrition Survey (NNS 2000), which were nationally representative surveys on 17,213 and 14,452 subjects respectively. In order to be nationally representative and to have sufficient representation of regions, urban and rural areas, sex and age groups, a two stage stratified sampling method with equal-sample-size was used.

During the data analysis with SPSS the complex sample procedure was used, using weighing factors based on the population structure stratified by ecological region, sex, age-group and area of residence in 2004 (Census, 2004) in order to ensure a fully national representative report of the result.

For both surveys, only approximately 3% of selected households (NNS 2000) or subjects (NAOS 2005) who were not able to be present at the surveys were replaced by other randomly selected households or subjects (with the same gender, age group of the same cluster) based on the available sample frame of each cluster, as recommended. Therefore, the study sample was sufficiently representative of Vietnamese adults at a national scale.

Definition of prehypertension

In the current thesis, we use two common hypertension classifications, i.e. the hypertension classification of the Seven Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7, launched in 2003) and the European Society of Hypertension/ European Society of Cardiology guideline (2013 ESH/ ESC). In the recently released JNC 8, definitions of hypertension and prehypertension not addressed, but thresholds for pharmacologic treatment were defined.[1] Hypertension was defined as SBP ≥140 mm Hg and/or DBP ≥90 mm Hg and/or self-reported current use of anti-hypertensive medication by both JNC 7 and 2013 ESH/ESC. The cut-off points for prehypertension defined by JNC 7 (SBP ≥120 and <140 mm Hg and/or DBP ≥80 and <90 mm Hg) was lower as recommended by the 2013 ESH/ESC guideline (SBP ≥129 and <140 mm Hg and/or DBP ≥85 and <90 mm Hg). Cohort studies have shown that the risk of CVD beginning at 115/75 mmHg doubles with each increment of 20/10 mm Hg.[2] Therefore, from the viewpoint of prevention, early recognition and life modification should be applied and the JNC 7 classification for prehypertension was used in Chapter 2. However, 2013 ESH/ESC classification was also used to facilitate the international comparison. The prevalence of prehypertension by 2013 ESH/ESC classification was considerably lower (i.e., 13.7% vs. 46.1% in men; 9.8% vs. 37.2% in women), and the total prevalence of combined prehypertension and hypertension was 32.9% vs. 62.5%.

Definition of overweight

The general overweight and obesity classification uses BMI ≥25 kg/m^2 and BMI ≥30 kg/m^2 as cut-off values.[3] However, for Asian population, lower the cut-off points have been recommended i.e. BMI ≥23 kg/m^2 and BMI ≥27.5 kg/m^2, respectively.[4] This is due to the fact that in Asian people the association of overweight and obesity with cardiovascular risk factors, including hypertension, starts at lower weights-for-height than in Caucasians.[4] the study by Nguyen et al. computed and searched for the shortest distance on receiver operating characteristic curves to define optimal BMI cut-offs that best predict hypertension in the Chinese, Indonesia and Vietnamese population. The overall and sex-stratified analyses suggested that BMI cut-offs of 23–24, 21–22.5, and 20.5–21 for Chinese, Indonesian, and Vietnamese adults, respectively were optimal in defining the increased risk of hypertension for these population with BMI above this cut-offs.[5] The use of even lower BMI cut-off values (21.2 and 22.1 kg/m^2 for men and 21.2 and 22.9 kg/m^2 for women) than those recommended for an Indo-Asian population yielded the optimal areas under the curve for an association with hypertension and diabetes, respectively.[6] Therefore, a BMI cut-off point of 23 kg/m^2 for classification of overweight has been suggested for Asian populations.[4,7] In this thesis, in addition to the BMI cut-off point of 25 kg/m^2, the cut-off value of 23 kg/m^2 was therefore used to describe the burden of BMI and associated hypertension in the Vietnamese population.

Measurements

Measurements of all collected indicators including anthropometry, BP, salt intake and sources and other lifestyle factors followed standardized methods by well-trained data collectors. The WHO STEPS manual for chronic disease risk factor surveillance (2003 and revised 2008)[8,9] was applied to collect data on behavioural risk factors (tobacco use, alcohol consumption, diet, physical activity) and physical measurement (body weight, body height, BP measurements).

BP measurement

In ***Chapter 2***, BP was measured according to WHO STEPS manual (2003).[8] However, the most updated manual[9] indicates that to have accurate estimates of BP three measurements instead of two measurements should be taken during the physical examination, and during data analysis the mean of the second and third readings should be used. By taking a third measurement if the first and the second measurements differed more than 10 mmHg in some cases the difference with the updated manual was less. It should be noted that our data on hypertension and prehypertension were obtained from two repeated measurements during 1 visit, whereas two independent visits are recommended in a clinical setting.[10] It has been shown that with a single visit the prevalence can be overestimated by 3% to 29%, and the actual prevalence of (pre)hypertension in our Vietnamese population may therefore be lower than reported in this thesis.[11] However, multiple measurements in a national survey with large sample size was difficult for logistic and financial reasons, and other population-based surveys used single visits as well. Hence, our results are well comparable with other studies.[12-14] Moreover, it has been shown that within-person variation in the outcome variable does not affect the strength of the association with its determinants,[15] which is important because these may provide clues for prevention programs.

In ***Chapter 5***, baseline BP was the average of measurements from separate three visits provided accurate BP's values. But at follow-up, BPs were obtained with only 1 visit, hence we may have had less power to detect the salt effect on BP due to less data on within-person variation. However, by taking the average of BP during the trial (at week 2, 4, 6 and 8) this variation could be reduced.

Salt intake measurement

In ***Chapter 4***, salt intake was measured by 24-hour urinary sodium excretion since it is considered as the gold standard for assessing salt intake.[16] Because of the large day-to-day variability in sodium intakes in developed countries, a single 24-hour urine collection is not sufficient to characterize the sodium intake of the individual.[17] On the other hand, as recommended by WHO, the mean sodium excretion in populations can be estimated from single 24-hour urine collection, with little error around the mean, by including sufficient number of 100–200 randomly selected subjects.[16] The survey was conducted on 121 participants who met this sample size requirement.

Complete urine collection, avoiding both under and over collection, is a critical issue when estimating of 24-hour sodium excretion. The two methods generally used to evaluate the completeness of 24-hour urine collection are measuring urinary creatinine concentrations, or assessing recovery using p-aminobenzoic acid (PABA). Each method has its strong and weak points. Assuming that the rate of urinary creatinine excretion is constant,[18] 24-hour excretion of creatinine has been used as a standard to exclude urine collections judged to be incomplete.[19-21] However, there is a wide range (1.7% up to 50%) in individual excretion of creatinine related to body mass[22] or muscle mass,[23] diet,[24] and physical activity,[23] and diseases related to muscle breakdown.[25] This large intra-individual variability in creatinine excretion and the effect of meat in the diet limit the utility of creatinine as a marker for the completeness of 24-hour urine collections.[26] By comparing five reported methods of using urinary creatinine to assess the completeness of 24-hour urine collection with the technique of using PABA, it is concluded that at least in well-motivated populations in which the proportion of incomplete urine is presumed to be small, the strategy of Knuimann et al.[27] using urinary creatinine, height and weight of the participant and consideration of the self-reported collection time and missing urine volume in the estimation of total volume shows the highest sensitivity and specificity therefore may be useful in the completeness's assessment of 24-hour urine collection.[28]

The use of PABA has been proposed as an alternative to the creatinine method.[29] At a dose of 240 mg (80 mg three times a day with meals), the mean recovery of PABA over a 24-hour period was 93% and the range between minimum and maximum values was 15% of the mean compared with 70% for creatinine excretion.[29] However, PABA recovery was lower with renal disease and old age.[30] Hydrolysis of acetylated metabolites occurs in the urine, and the free amine groups become available for detection by chemical analysis; a number of drugs including sulphonamides, folic acid, paracetamol, phenacetin and furosemide contain amine groups or may be metabolized to them, and erroneously high PABA recovery rates might therefore be obtained in individuals taking these drugs.[29] The technique relies on the participant taking their tablets as instructed at intervals during the 24-hour period; missing a tablet, or taking the tablets at the wrong times, might result in complete urine collections being falsely rejected.[31] Furthermore, an exhibition of an acute allergic reaction with oedema was reported after using PABA. Thus the utility and the safety of the PABA technique for population surveys have not been established, which is important for a survey in an emerging economy such as Vietnam, as the costs of PABA lab analyses are high.

In the absence of a reliable biochemical technique to validate completeness of 24-hour urine collections, rigorous survey methods to minimize under- and also over-collection were adopted. The INTERSALT and INTERMAP studies were large studies that adopted these methods as well.[32,33] This involved both the beginning and end of the 24-hour collection being supervised and timed by the research team, clear instruction on the method of urine collection, explaining the importance of collecting a complete sample to each participant, and provision of a sufficient number of standard collection jars for the 24-hour period. Immediately before starting the collection, the participant was asked to void his or her bladder. All urine voided from that moment onwards was to be collected until the same time the following day when either the participant should re-visit the clinic or the end of the collection should be supervised in the home. To prevent deterioration of the samples, the collection jars were pre-treated with boric acid as preservative. Each participant was provided with a suitable bag to carry and protect the jars from spillage and to avoid embarrassment. At about the same time the next day, the participant was asked to empty his or her bladder completely, and the final urine specimen was collected. At this point the collection time was recorded; collections within the range 20–28 hours were acceptable (corrected to 24 hours in the data analysis). On completion of the urine collection, each participant was asked a simple set of questions about completeness. If the participant responded that "more than a few drops" of urine were lost during the collection, it was considered invalid and the participant was asked to repeat the collection, or a replacement participant was recruited. The total volume of urine collected was measured using a specially-devised linear measuring scale, and the complete sample mixed thoroughly before aliquots were taken for laboratory analysis.[32]

In ***Chapters 4 and 5***, salt intake was assessed by 24-hour sodium excretion. To ensure the completeness of 24-hour urine collection, the above survey technique was applied and urinary creatinine measurement was used to further assess completeness. Furthermore, because 24-hour direct food weighing was implemented at the same time with the 24-hour urine collection for each participant, the presence of data collectors in the households enabled supportive supervision for urine collection (***Chapter 4***). Therefore the sodium intake measurement in our Vietnamese population can be considered reliable and provides an acceptable accurate estimate of daily salt intake. Because of the limitation of using creatinine measurement, we decided to present the findings for both the total as the complete urine collection only, instead of discarding the incomplete ones The subjects with complete 24h urine collection based on urinary creatinine excretion had significantly higher mean 24-hour sodium excretion (204.1 ± 56.8 mmol, or 11.7 ± 3.3 g salt) as compared to subjects with incomplete urine collection (163.4 ± 49.6 mmol, or 9.4 ± 2.9 g salt, $p<0.05$).

Assessment of dietary sodium sources

Dietary sodium sources were assessed by direct food weighing method using the standard technique[34] during the same time span of the 24-hour urine collection (***Chapter 3***). OMRON digital scales with maximum weight of 2 kg and accuracy at 0.1 g were used and calibrated daily. The data collectors were well-trained before the survey and closely supervised during the data collection. The data collectors stayed in the households to weigh and record all food items prepared for each meal, from their raw forms until ready-to-eat dishes.

Specific sources of error with regard to sodium intake by dietary survey method have been reported, including difficulties in estimating the amount of sodium chloride added during cooking (including in restaurants) and at the table; variation in the proportion of salt added during cooking that is retained by the food; salt left behind on the plate; variation in the sodium content of manufactured foods; and variation in sodium concentration of local water supplies.[35,36] These sources of error have been minimized in our study. All the condiments including salt, seasonings, sauces and monosodium glutamate (MSG) added during food preparation, cooking or adding, or dipping at the table were weighed and recorded. The portions of foods eaten by the participants were weighed and recorded before eating and also after eating if anything was leftover. Ready-to-eat foods bought outside and eaten at home were all weighed and recorded. Salt content of these foods was then computed based on the recipes and food composition table. Participants were also asked to provide a double portion of any food that the participants had consumed out of home for weighing. In case the participants could not provide the double portion, an interview using local dining utensils or the album of food and portion size used for dietary survey was used to obtain the weight of food eaten. Recipes of those ready-to-eat foods were obtained by interviewing food vendors if material or seasoning contents was unknown or from the Vietnam food composition table. The sodium content of processed and restaurant foods is especially important in the developed countries, as these foods contribute three-quarters or more of the sodium intake of a typical developed country diet.[37] However, ready-to-eat foods or processed foods were not commonly consumed and out-of home eating was not commonly practiced in our study population, as in many other Asian populations,[37] and therefore the errors due to estimation of sodium content from these food sources is probably small. Furthermore, instead of assessing individual absolute amounts of sodium intake, we aimed at collecting data on average sodium content from different food sources (natural food, processed food and added condiments). The sodium intake estimated from the direct food weighing method and 24h-urinary excretion method were significantly correlated, although the size of the correlation was modest (Spearman correlation $r=0.29$, $p<0.001$) as (***Chapter 3***) as compared to the $r=0.56$ in the global data reported.[38] The quality of the food composition table for sodium content may not be optimal, particularly processed foods without sodium content could explain for this modest correlation.

In conclusion, the measurements of anthropometry, BP, sodium intake and its dietary sources may be considered sufficiently accurate and reliable in the prevalence study among Vietnamese adults described in this thesis.

INTERPRETATION OF FINDINGS

Prevalence of hypertension and its determinants

Urban versus rural areas

In ***Chapter 2***, the prevalence of hypertension in women aged 25–64 years was higher in rural areas than in urban areas (16.2% vs. 13.9%). Prehypertension, however, was more prevalent in rural than in urban areas (43.0% vs. 33.6%, p<0.001) for both sex. Overall, prehypertension and hypertension combined affected more rural than urban residents (63.8% vs. 54.3%, p<0.001) (***Chapter 2***). After adjusting for major risk factors, the differences remained, i.e., they could not be explained by differences in BMI, physical activity, alcohol consumption and education. This was especially clear for the women, with adjusted ORs higher than 2. In other populations, the similar trend was also observed in some population showing more hypertension in urban areas. For example in Thailand, a higher adjusted prevalence of prehypertension in rural areas has been reported, again for women,[12] whereas adjusted data from Korea showed similar prevalence in urban and rural areas.[39] The 2007–2008 national survey in China[40] showed that in economically developed regions, the prevalence of hypertension was slightly higher among rural residents than among urban residents (31.3% vs. 29.2%, p=0.001). The disparity in the prevalence of hypertension between urban and rural areas disappeared when studying women (24.0% vs. 24.0%, p=0.94) and individuals living in the northern region (31.6% vs. 31.2%, p=0.51). Multivariable regression analysis showed that urban residence was inversely correlated with hypertension after adjustment for sex, age, a family history of hypertension, educational level, heart rate, overweight, obesity, central obesity, diabetes, serum triglyceride levels, serum cholesterol levels, level of economic development. With economic development in rural regions, urbanization and associated lifestyle and diet may explain the convergence in the prevalence of hypertension between persons who live in urban settings and those who live in rural areas.[41]

We can only speculate on the causes of the higher prevalence of hypertension in women and/or rural residents. First, Vietnam has large geographic differences, with 8 ecological regions; differences in food patterns exist across these regions as well as in rural vs. urban areas. In urban areas, there is better economic development and education, for example urban residents have better knowledge of, and accessibility to, modern equipment for food preservation, such as refrigerators. In rural areas the use of salt to preserve food is still common practice. Moreover, due to poor economic conditions, rural people often cook highly salty dishes to consume together with a large amount of rice in order to meet their energy requirements. In addition, lower education in general and lack of health information in particular might also contribute to continuing high salt consumption in rural as compared to urban areas.

Hypertension and salt intake

In the study on the prevalence of hypertension and the association with determinants (***Chapter 2***), national salt intake data were not available. Therefore, we could not confirm the cross-sectional association of hypertension and salt intake in our population. We conducted a separate survey to investigate sodium intake using 24-hour urine collection in a rural community (***Chapter 4***). The findings indicated that the mean salt equivalent urinary excretion was 10.8 g/d (188 mmol sodium/24 hour) which is more than twice higher than the WHO recommended upper level of 5 g/d.[4,7] The association of salt intake and hypertension in Vietnamese population however was confirmed by the reduction of both systolic BP and diastolic BP after the salt reduction intervention in ***Chapter 5***.

Overweight and obesity

The estimated average increase in the prevalence of overweight amounted to 0.6% per year (***Chapter 2***), which was almost twice as that of 0.3% per year over the period of 1992–2002.[42] If this trend would continue, the prevalence of overweight and obesity is expected to double in the next 5 years.

Overweight and obesity are associated with many physiological and metabolic changes that promote hypertension.[43] The findings in ***Chapter 2*** show that using the Asian BMI cut-off point of 23 kg/m^2, overweight men and women had a 4.1 and 2.6 times higher risk of having hypertension, respectively, compared with the normal BMI groups, independent of age, education, area of residence, alcohol consumption, smoking and physical activity. The cut-off point of 23 kg/m^2 was used to describe the association of overweight and hypertension, since the Asian population has and increased risk for chronic diseases at lower BMI as discussed earlier. Therefore, it is to be expected that the rapid increase of overweight and obesity will contribute to a substantial increase in hypertension among the Vietnamese population, particularly among urban residents and women who suffering from more overweight and obesity (***Chapter 3***).

Dietary salt intake

Ideally, national data on sodium intake and dietary sodium sources should be collected to investigate the association of sodium intake and BP in the Vietnamese population. However, with limited resources, in the scope of this thesis a small survey was conducted in a rural community of Hanoi. These preliminary data indicate that salt intake in Vietnam is high, which calls for a larger nationwide investigation into salt consumption levels and dietary sources of salt. As presented in ***Chapter 3***, urinary salt excretion in complete collectors was almost 12 g/d. Holbrook et al. reported that about 86% of ingested Na is excreted into urine at a usual room temperature.[44] After accounting for sweat loss, total daily salt intake in Vietnamese adults may even amount to 13.6 g/day. This estimated sodium intake 2–3 fold higher than the WHO's recommendation (<5 g/d).[45] This may be responsible for high (pre)hypertension despite relatively low BMI (21 kg/m^2) in the Vietnamese population.

BP reduction after salt substitution

The participants were randomized to either the control or intervention group and socio-economic status and other major confounders were similar in the two groups. However, baseline systolic BP was 2.2 mmHg higher in the intervention than the control group which is a limitation of the present trial. The trial was totally blinded with 100% of the studied participants, health workers and data collectors were not aware of the allocated treatments and the type of trial products that were consumed. Therefore, we can assume that the changes in salt intake and BP resulted from use of the test products. Although the net reduction in sodium intake was larger in the intervention group, a decrease was also observed in the control group. This might be due to the awareness about the aim of the study, which was explained to all participants before the study to obtain their informed consent and fulfil the ethics requirements.

Other modifiable risk factors

Physical activity

An inverse dose-response association between levels of recreational physical activity and risk of hypertension is well documented.[46,47] In ***Chapter 2***, physical activity was independently associated with lower risk of having hypertension, in both men (OR=0.61, 95% CI 0.48–0.80) and women (OR=0.7, 95% CI 0.53–0.92), respectively. Although 81.4% of the adult population was classified as having high level of physical activity, this proportion was only 56.5% among urban residents. The higher level of industrialization promotes a lifestyle with less physical activity and more sedentary habits among the Vietnamese population. Particularly in urban areas, increasing use of transportation by motorbike, bus, or car, instead of walking; taking lift instead of using stairs, using mechanic equipment and machine at work and for housework, sitting long hours in front of computer and internet, and relaxing by watching TV and online entertainment, as well as lack of space or land for physical activity and sports, all bring people to more sedentary lifestyle. Data presented in this thesis highlight the need for promoting physical activity, particularly among men and the urban population, for hypertension prevention.

Alcohol

Alcohol intake increases BP in a dose response-manner.[48-50] The prevalence or incidence of hypertension was found to be higher in adult population from cross-sectional, population-based and cohort studies, ingesting more than 30 g/day.[50-52] Similarly in our Vietnamese population, men using >30 g ethanol/d had 1.6 times higher risk of having hypertension than non-drinkers (***Chapter 2***).

Alcohol use is highly prevalent among Vietnamese men (40% high users, with beer and spirits being most common) but not in women (3%) (***Chapter 2***). Our results suggest that actions may be required to prevent excessive alcohol consumption among men.

Smoking

Hypertension was more common in ex-smokers compared to current or never smokers was observed in several population[53,54] and this was also observed in our Vietnamese nationwide study (***Chapter 2***). However, the association between hypertension and smoking was not observed after taking other risk factors, such as BMI, into account. The absence of an association between hypertension and smoking after adjustment for other risk factors was also reported in other populations.[13,55,56] Generally, lower BP values have not been observed after chronic smoking cessation.[57] This may be due to concomitant increase in body weight. In an earlier study on Vietnamese men hypertension was associated with smoking in a dose-response manner when characterized as number of years of smoking and lifetime cigarette consumption and when adjusted for age, sex, BMI and alcohol use, but was not associated with current smoking status.[58] However, with smokers accounted for 82.7% men , and the overall prevalence of hypertension and prehypertension was 70.1%

(current smokers) and 74.0% (ex-smokers) compared to 55.9% in non-smokers, smoking may be related raised BP in Vietnamese men, but these results warrant confirmation in other epidemiological studies.

PUBLIC HEALTH IMPLICATIONS

The present thesis indicates that raised BP (20.7% hypertension and 41.8% prehypertension) is a major public health problem in Vietnam, putting 62.5% (or about 24 millions) of the adult population aged 25–64 years at increased risk of cardiovascular disease morbidity and mortality (***Chapter 2***). CVD risk increases throughout the range of BP, starting already at levels of 115/75 mm Hg.[2] A large group of people fall within the clinically "normal" range for BP (i.e. below 140 mmHg systolic) but have BP levels above optimal levels. Treatment strategies restricted to individuals with clinically diagnosed hypertension will therefore not be sufficient to prevent BP -related disease. The prevalence of prehypertension among Vietnamese adults was higher than that of the overall pooled prevalence of prehypertension worldwide (38%) or the reported 36% among Asian individuals,[14] although it must be noted that prevalence figures in this thesis may be overestimated because they are based on non- repeated BP measurements. This is the first time prehypertension was reported in Vietnam and results indicate the need for lowering population BP before progression to hypertension takes place.

The reported low proportions of hypertension awareness (25.9%), treatment (12.2%) and control (2.8%) require increased efforts regarding education, detection, and treatment. Health communication and education should be implemented more widely and effectively to improve knowledge and raise awareness of the population about raised BP, its causes and consequences for better prevention and detection. Health systems, including personnel and equipment, should be strengthened for better treatment and control of hypertension.

This thesis also indicates high risk groups for raised BP, namely men, rural residents, and individuals who are overweight or obese, older, lower educated, physically inactive, alcohol drinkers and high salt consumers. Prevention strategies should give priority to these risk groups. Improving health and nutrition information, education and communication on the morbidity and mortality burden of raised BP and its risk factors, is necessary to raise awareness and promote appropriate lifestyle changes among Vietnamese adults. Lowering overweight and obesity, and promoting physical activity should be given particular attention in urban areas. Excessive alcohol consumption should be reduced to prevent and reduce prehypertension and hypertension among men. The reformulation of processed foods and condiments by food industry, especially sodium reduction, will benefit the population at large.

Salt reduction has proved to be the most cost-effective measure for prevention and control of hypertension.[59] Information on dietary sources of sodium is most important to plan salt/sodium reduction. Like for many other Asian countries with the majority of dietary sodium coming from high-sodium condiments added during cooking and at the table, reducing this sodium source (accounts for 81% of total dietary sodium) is critical for sodium reduction in Vietnam. High sodium condiments such as mixed seasoning (bot canh and hat nem 35%), fish sauce (31%) or soy sauce and others are important target for sodium reduction rather than pure salt which accounted for only 6% of total dietary sodium.

Reduction of added salt/sodium requires two main strategies i.e. a population campaign to raise consumer's awareness and promoting behaviour change, and salt substitution. Behaviour change requires a long process with enormous investment and efforts to achieve impact on knowledge, perception and then behaviour change, particularly, on changing cooking behaviour relating to salty taste eating. In this context, using sodium-reduced and potassium-enriched salt and condiments show an advantage in reducing sodium intake and increasing potassium intake without requiring change of cooking behaviour and salty taste preference. Partial replacement of sodium by potassium has been implemented by various food companies. The use of potassium containing salt substitutes has been shown to lower sodium intake and BP in several populations.[60,61] In our studied population (***Chapter 4***), discretionary salt contributed only 6.1% to total sodium intake, and therefore bot canh, a traditional mixed seasoning which accounted for 35.1% of dietary sodium, was also reformulated. We developed potassium containing salt and bot canh at the National Institute of Nutrition of Vietnam. The products underwent sensory testing and appeared to be highly accepted by the community. The potassium containing products provided 67% (discretionary salt) and 60% ('bot canh') less sodium as compared to regular products. Eight-week consumption of potassium containing salt substitutes decreased the median 24-hour sodium excretion by 28.5 mmol/d (1.6 g/d salt) compared to the control group (***Chapter 5***). The mean change in BP in the intervention compared to the control group was -2.6 mmHg (95% CI -4.6 to -0.5, p=0.013) for systolic BP and -1.6 mmHg (95% CI -3.0 to -0.2, p=0.024) for diastolic BP. With these reductions in sodium intake and BP, it is estimated that the number of deaths from strokes would be reduced by 12.5% and number of deaths from CHD by 9.1%.62 Hence, this is a method for sodium reduction in

Vietnam with high potential, as discretionary sodium accounted for the main source of sodium intake. In addition to the strategy for the reduction of discretionary salt/sodium, appropriate strategies to reduce salt/sodium content in processed food should also be promoted in cooperation with food industries.

Overweight and obesity are determinants of hypertension but are also through other pathways, such as lipid metabolism and diabetes, important risk factors for cardiovascular diseases. The estimated average increase in prevalence of overweight was double in the period of 5 years, amounted to about 2.6 million (BMI $\geq$25 kg/m^2) or 6.5 million when using the Asian cut-off (BMI $\geq$23 kg/m^2) of adults were overweight (***Chapter 3***). Limiting the rapid increase in overweight and obesity will contribute to the prevention of hypertension and cardiovascular diseases. The shift to higher BMI or the increase in overweight was observed nationwide, but more in urban areas, women and higher income groups, and therefore appropriate intervention strategies should be applied to these subgroups. It is important to mention that Vietnam is undergoing a nutrition transition with a shift towards higher BMI and overweight, but underweight has remained highly prevalent in all subgroups. Particularly women are at higher risk of having both underweight and overweight compared to men. Prevention programs and interventions should take the double burden of nutrition problem into consideration to avoid worsening the severity of underweight when spending efforts in reducing overweight. Interventions against early childhood undernutrition, particularly stunting, is also required to prevent both underweight and overweight, and hypertension and cardiovascular diseases in adulthood.[63]

Salt iodization has been implemented worldwide for many years for controlling iodine deficiency disorders. Therefore iodine deficiency should also be investigated when implementing salt reduction interventions. The baseline data of the trial (***Chapter 5***) showed that iodine deficiency was prevalent in the studied population, with 72% in the control and 66% in the intervention group. This finding indicated that at current intake level of salt and other high-salt condiments in this population, iodine requirements were not met. Currently, salt iodization is not mandatory in Vietnam, and in parallel with iodized salt there is also non-iodized salt available on the market. In addition to iodized salt, iodized 'bot canh' is available in the market on voluntary basis, but all other salty condiments are not iodized. Our finding suggests that the current salt and seasoning commonly consumed by this population do not ensure sufficient iodine intake. Higher iodine content for salt and bot canh is recommended, or iodization should also be applied to other condiments or other food vehicles. The urinary iodine excretion of both studied groups significantly increased after consuming iodized salt and iodized 'bot canh', leading to a reduction of iodine deficiency to 36% and 41% in the control and intervention group, respectively. Therefore, regular consumption of sufficiently iodized sodium-reduced and potassium-enriched salt and 'bot canh' is warranted to ensure an adequate iodine status of consumers.

FUTURE RESEARCH DIRECTIONS

The present thesis provides several directions for further research. Future studies should investigate why raised blood pressure was more prevalent in rural areas as compared to urban areas. Also the trend in these subpopulations is important to monitor. For the prevention of hypertension and related cardiovascular diseases, a national data on salt intake and dietary sodium sources, and diversity in related eating habit in different regions are required, for better planning and implementation of sodium reduction strategies. These strategies should focus on the discretionary sodium reduction such as development of more variety of low-sodium salty condiments, and reformulation or replacement of sodium content in processed foods. In addition, appropriate population interventions for controlling the risks of hypertension, particularly overweight-obesity and promoting lifestyle modification for the Vietnamese population are needed.

Data on Vietnamese population showed that potassium intake (45 mmol/day) (***Chapter 5***) met only half of the recommended dietary intake[64] and low calcium intake and vitamin D deficiency were prevalent among women and children[65] and 52% magnesium deficiencies among preschool children.[66] Therefore studies on the role of other minerals such as potassium, and calcium and probably magnesium in hypertension, particularly in low consumption population like Vietnam are required to arrive at a comprehensive prevention strategy.

The thesis also pointed out that iodine deficiency were prevalent among studies population. Therefore, iodine deficiency as well as the effectiveness of salt iodization should be investigated. Investigation strategies such as enabling a mandatory environment, iodine content or other condiment or food as vehicles for iodization are required.

CONCLUSION

Hypertension is a major public health problem among Vietnamese adults, both in urban and rural areas. The prevalence of prehypertension was higher than the average preva-

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lence of developing countries, and more common among rural residents, stressing the public health significance of raised BP and its cardiovascular consequences in rural areas. Low awareness, treatment and control of hypertension contribute to the burden of hypertension. The double burden of nutrition still exists, with an increase in overweight and obesity in parallel with a reduction but still high prevalence of undernutrition, particularly in women. Different strategies of life modifications for different risk groups, such as older age, lower education, overweight and obesity, excessive use of alcohol, physical inactivity and urban vs. rural residents, are required to tackle the raised BP problem. With added salt and condiments into food during food preparation and eating at the table being the major source of dietary sodium, development and consumption of sodium-reduced and potassium-enriched condiments such as salt and 'bot canh' can be a valuable strategy to reduce sodium intake and BP in the population. Iodine deficiency was prevalent among the study participants. Salt iodization should hence be reconsidered to make mandatory, or iodization should be extended to other condiments and food vehicles, particularly in the context of salt reduction strategy.

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Summary

The morbidity and mortality patterns have changed quickly during the last decades, with a reduction in infectious diseases in parallel with a rapid increase in non-communicable diseases (NCDs), leading to the so-called double burden. It was estimated that in 2008 NCDs accounted for 75% of all deaths in Vietnam, among which raised blood pressure caused 40% of all death. Hence, it is clear that there is an urgent need for better understanding of risk factors and appropriate population-based interventions to control and prevent hypertension and its related cardiovascular diseases in Vietnam.

Therefore, the aim of the current thesis is to examine BP and its determinants in the Vietnamese population as well as to investigate a potential population-based intervention for BP control in Vietnam.

More specifically, the following research questions are addressed:

1. What is the prevalence of hypertension and prehypertension and its related risk factors in the general population of Vietnamese adults? (***Chapter 2***)
2. What is the trend of BMI distribution and national prevalence of overweight and obesity in Vietnamese adults? (***Chapter 3***)
3. What is the sodium intake in Vietnam, and which are the main dietary sodium sources? (***Chapter 4***)
4. Does consumption of sodium-reduced and potassium-enriched salt and seasoning in replacement of regular salt and seasoning lower sodium intake and BP in Vietnamese adults with prehypertension and hypertension? (***Chapter 5***)

We used the national adult overweight and obesity survey to investigate the prevalence of hypertension and prehypertension and its risk groups among Vietnamese adults in ***Chapter 2***. The national nutrition survey was also used to study the shift in double burden of nutrition from underweight to overweight and obesity among adult population in the period of 2000 and 2005 in ***Chapter 3***. The sodium intake and dietary source in Vietnamese diet was reported in ***Chapter 4***. The sodium-reduced and potassium-enriched salt and a Vietnamese traditional seasoning 'bot canh' has been developed and their effects on reducing sodium intake and BP has been investigated in a randomized double blind clinical trial and documented in ***Chapter 5***. The results, methodological issues, public health implications and future research direction were discussed in ***Chapter 6***.

Hypertension and prehypertension were prevalent among Vietnamese adults, particularly in men with overweight and excessive alcohol consumption, rural women and those with lower physical activity and education levels.

In ***Chapter 2*** we investigated the national prevalence of hypertension and prehypertension, as well as their association with determinants, in Vietnamese adults. The overall census-weighted JNC7-defined prevalence of hypertension was 20.7% (95% CI 19.4–22.1); the prevalence of prehypertension was 41.8% (95% CI 40.4–43.1). Hypertension and prehypertension were more prevalent in men than in women and more prevalent in rural than in urban areas. Higher age, overweight, alcohol use (among men) and living in the rural areas (among women) were independently associated with a higher prevalence of hypertension, whereas higher physical activity and education level were inversely associated. Age, BMI, and living in the rural areas were independently associated with an increased prevalence of prehypertension. Among the hypertensives, 25.9% were aware of their hypertension, 12.2% were being treated, and 2.8% had their blood pressure under control; among the treated hypertensives, 32.4% had their blood pressure under control.

There was a shift to higher prevalence of overweight and obesity and lower prevalence of underweight among Vietnamese adults in 2005 as compared to 2000.

Overweight and obesity or BMI was strongly increased the risk of raised blood pressure as shown in ***Chapter 2***, therefore in ***Chapter 3*** we explored the trend of BMI distribution and national prevalence of overweight and obesity in Vietnamese adults between 2000 and 2005 among different groups. The distribution of BMI across the population and population groups indicated a shift towards higher BMI levels in 2005 as compared to 2000. The nationwide prevalence of overweight (BMI ≥25 kg/m^2) and obesity (BMI ≥30 kg/m^2) was 6.6% and 0.4% respectively in 2005, almost twice the rates of 2000 (3.5% and 0.2%). Using the Asian BMI cut-off of 23 kg/m^2 the overweight prevalence was 16.3% in 2005 and 11.7% in 2000. In contrast, the underweight prevalence (BMI <18.5 kg/m^2) of 20.9% in 2005 was lower than the rate of 25.0% in 2000. Women were more likely to be both underweight and overweight as compared to men in both 2000 and 2005. Urban residents were more likely to be overweight and less likely to be underweight as compared to rural residents in both years. The shifts from underweight to overweight were clearer among the higher food expenditure levels.

Excessive sodium intake did exist in most of the studied population and condiments added during cooking and at the table responsible for 81% of total sodium intake.

Although having lower prevalence of overweight and obesity raised blood pressure (hypertension and prehypertension) was more prevalent in rural than in urban areas. Therefore sodium intake, with well-established association to raised blood pressure, and dietary sodium sources were investigated using 24-hour urine and 24-hour food weighing methods in a rural population (***Chapter 4***). The sodium intake was estimated from 24-hour sodium excretion in urine. The mean 24-hour sodium excretion was 188.6 ± 57.5 mmol (4.3 g) or 10.8 ± 3.3 g salt/day. Men had higher mean 24-hour sodium excretion (196.8 ± 56.9 mmol or 4.5 g) as compared to women (181.1 ± 57.4 mmol or 4.2 g); 97.5% of the men and women had a salt intake higher than the WHO recommendation of less than 5 g/day. Sodium in condiments added during cooking or eating at the table accounted for 81% of sodium intake. Processed foods contributed 11.6% and natural foods 7.4%. Regarding the condiments, the largest source was the mixed seasoning ('bot canh', 35.1% of total); 31.6% of total dietary sodium was provided by fish sauce, 7.4% by monosodium glutamate and 6.1% by table salt.

Replacing regular salt and 'bot canh' with sodium-reduced and potassium-enriched condiments could make a relevant contribution to lowering sodium intake and blood pressure in (pre)hypertensive Vietnamese adults.

The effects of using sodium-reduced and potassium-enriched salt and 'bot canh', a Vietnamese traditional condiment, on the sodium intake and blood pressure in (pre) hypertensive Vietnamese adults have been explored by a randomized double-blind placebo-controlled trial reported in ***Chapter 5***. During intervention, the median 24-hour sodium excretion decreased by 52.3 mmol in the intervention group and by 23.8 mmol in the control group, a net difference of 28.5 mmol (1.6 g/d salt). The mean change in BP in the intervention compared to the control group was -2.6 mmHg (95% CI -4.6 to -0.5, p=0.013) for systolic BP and -1.6 mmHg (95% CI -3.0 to -0.2, p=0.024) for diastolic BP. In addition, ensuring the iodine concentration in salt and condiments led to significant reduction of the prevalence of iodine deficiency in both groups (from 72% to 36% in controls, from 66% to 41% in intervention group).

In conclusion, raised blood pressure, including hypertension and prehypertension, is a nationwide public health problem in Vietnam. Overweight and obesity group, men with excessive alcohol use, and rural residents are high risk groups for raised BP while groups of higher physical activity and higher education levels are at a lower risk. Double burden of nutrition exists with the shift from underweight to overweight among different groups nationwide but to a larger extent in urban areas than in rural areas. Most of the (studied) population has excessive sodium intake and most of dietary sodium intake comes from sodium added during cooking and at the table. Therefore, in parallel with appropriate interventions to control body weight and alcohol use and the promotion of physical activity and nutritional education, replacing regular salt and condiments (i.e. 'bot canh') with sodium-reduced and potassium-enriched salt and condiments could be a valuable public health measure to lower sodium intake and blood pressure in the Vietnamese population.

Tóm tắt
(Vietnamese summary)

Mô hình bệnh tật và tử vong đã thay đổi nhanh chóng trong mấy thập kỷ vừa qua, song song với việc giảm các bệnh nhiễm trùng là sự gia tăng nhanh chóng các bệnh mạn tính không lây, dẫn đến tình trạng được gọi là gánh năng kép. Theo ước tính, ở Việt Nam năm 2008 có khoảng 75% trường hợp tử vong là do các bệnh mạn tính không lây, trong đó 40% là do tăng huyết áp. Rõ ràng vấn đề cấp bách đặt ra là cần phải có hiểu biết rõ ràng hơn về các yếu tố nguy cơ và các can thiệp cộng đồng phù hợp để phòng chống tăng huyết áp và các bệnh tim mạch liên quan ở Việt Nam.

Do đó, mục tiêu của luận văn này là tìm hiểu về huyết áp và các yếu tố liên quan ở quần thể dân cư Viêt Nam, cũng như nghiên cứu can thiệp cộng đồng tiềm năng nhằm kiểm sóat huyết áp ở Việt Nam.

Cụ thể hơn, các câu hỏi nghiên cứu sau sẽ được tìm hiểu:

1. Tỷ lệ tăng huyết áp và tiền tăng huyết áp ở quần thể dân cư trưởng thành Việt Nam là bao nhiêu và các yếu tố liên quan là gì? (***Chương 2***).
2. Xu hướng phân bố BMI và tỷ lệ thừa cân và béo phì ở người trưởng thành Viêt Nam là bao nhiêu? (***Chương 3***)
3. Khẩu phần natri của người Việt Nam là bao nhiêu và đâu là nguồn cung cấp natri chính trong khẩu phần? (***Chương 4***)
4. Việc sử dụng muối và gia vị giảm natri và bổ sung kali thay thế cho muối và gia vị thông thường có làm giảm lượng natri tiêu thụ trong khẩu phần và huyết áp của người trưởng thành Việt Nam có tăng huyết áp và tiền tăng huyết áp không ? (***Chương 5***).

Số liệu từ cuộc Tổng điêu tra thừa cân và béo phì ở người trưởng thành năm 2005 được sử dụng để tìm hiểu tỷ lệ tăng huyết áp và tiền tăng huyết áp cũng như các nhóm nguy cơ ở người trưởng thành Việt Nam được trình bày ở ***Chương 2***. Cuộc Tổng điều tra dinh dưỡng toàn quốc năm 2000 cũng được sử dụng để nghiên cứu sự dịch chuyển gánh nặng kép về dinh dưỡng từ nhẹ cân sang thừa cân và béo phì ở người trưởng thành trong giai đoạn 2000 và 2005 được trình bày ở ***Chương 3***. Khẩu phần natri và nguồn cung cấp natri khẩu phần trong chế độ ăn của người Việt Nam được trình bày ở ***Chương 4***. Muối và bột canh (một loại gia vị truyền thống phổ biến của Việt Nam) được làm giảm hàm lượng natri và bổ sung kali đã được phát triển và hiệu quả của việc tiêu thụ loại muối và bột canh này tới việc giảm khẩu phần natri và huyết áp được nghiên cứu trong một nghiên cứu thử nghiệm lâm sàng ngẫu nhiên, mù kép, có đối chứng được trình bày ở ***Chương 5***. Kết quả, các vấn đề về phương pháp nghiên cứu, ứng dụng trong lĩnh vực sức khỏe cộng đồng và định hướng nghiên cứu trong tương lai được bàn luận ở ***Chương 6***.

Tăng huyết áp và tiền tăng huyết áp phổ biến ở người trưởng thành Việt Nam, đặc biệt ở nam giới thừa cân và uống quá nhiều rượu, phụ nữ nông thôn và những người có mức hoạt động thể lực thấp, trình độ học vấn thấp.

Chương 2 trình bày về tỷ lệ tăng huyết áp và tiền tăng huyết áp, và các yếu tố liên quan ở người trưởng thành Việt Nam. Theo phân loại của JNC 7, tỷ lệ tăng huyết áp là 20,7% (95% CI 19,4–22,1), tỷ lệ tiền tăng huyết áp là 41,8% (95% CI 40,4–43,1). Tăng huyết áp và tiền tăng huyết áp phổ biến ở nam nhiều hơn ở nữ và ở nông thôn nhiều hơn thành thị. Tuổi cao hơn, thừa cân, uống rượu, bia quá nhiều (ở nam giới) và sống ở nông thôn (đối với nữ giới) liên quan độc lập với tỷ lệ tăng huyết áp cao hơn, trong khi đó mức hoạt động thể lực và trình độ học vấn cao hơn lại có quan hệ ngược chiều với tỷ lệ tăng huyết áp. Tuổi, BMI và sống ở nông thôn có quan hệ ngược chiều với tỷ lệ tiền tăng huyết áp. Trong số những người tăng huyết áp, chỉ có 25,9% biết bản thân bị tăng huyết áp, 12,2% được điều trị, và 2,8% kiểm soát được huyết áp; trong số những người bị tăng huyết áp được điều trị, có 32,4% kiểm sóat được huyết áp.

Có sự dịch chuyển sang tỷ lệ thừa cân và béo phì cao hơn song song với tỷ lệ nhẹ cân thấp hơn ở người trưởng thành Việt Nam trong vào năm 2005 so với năm 2000.

Thừa cân và béo phì hay BMI cao hơn làm tăng rõ rệt nguy cơ tăng huyết áp được trình bày ở ***Chương 2***, do đó ***Chương 3*** tập trung đi vào tìm hiểu xu hướng phân bố BMI và tỷ lệ thừa cân và béo phì ở người trưởng thành Việt Nam trong gia đoạn 2000 và 2005 ở các nhóm đối tượng khác nhau. Sự phân bố BMI theo các quần thể dân cư cho thấy sự dịch chuyển về phía BMI cao hơn vào năm 2005 so với năm 2000. Tỷ lệ thừa cân (BMI ≥25 kg/m^2) và béo phì (BMI ≥30 kg/m^2) lần lượt là 6,6% và 0,4% vào năm 2005, gần gấp đôi so với tỷ lệ của năm 2000 là 3,5% và 0,2%. Nếu dùng ngưỡng phân loại BMI khuyến cáo cho người châu Á là 23 kg/m^2 thì tỷ lệ thừa cân là 16,3% năm 2005 và 11,7% năm 2000. Ngược lại, tỷ lệ nhẹ cân (BMI <18,5 kg/m^2) là 20,9% năm 2005 thấp hơn 25,0% năm 2000. Phụ nữ có nguy cơ cao hơn đối với cả tình trạng nhẹ cân lẫn thừa cân so với nam giới ở cả hai thời điểm 2000 và 2005. Người dân thành thị có nhiều nguy cơ thừa cân hơn và ít nguy cơ nhẹ cân hơn so với người dân nông thôn ở cả 2 thời điểm. Sự dịch chuyển từ nhẹ cân sang thừa cân được quan sát thấy rõ hơn ở các nhóm có chi phí cho ăn uống cao hơn.

Khẩu phần thừa natri tồn tại ở hầu hết quần thể nghiên cứu và natri có trong gia vị cho vào trong quá trình nấu ăn và trong lúc ăn chiếm tới 81% tổng khẩu phần natri.

Mặc dù tỷ lê lệ thừa cân và béo phì thấp hơn, tăng huyết áp và tiền tăng huyết áp vẫn phổ biên ở vùng nông thôn hơn vùng thành thị. Do vậy, khẩu phần natri, vốn đã được chỉ ra có mỗi liên quan với tăng huyết áp, và nguồn cung cấp natri khẩu phần đã được nghiên cứu sử dụng phương pháp thu thập nước tiểu 24 giờ và cân đong trực tiếp thực phẩm chế biến và tiêu thụ trong cùng 24 giờ ở cộng đồng dân cư nông thôn (***Chương 4***). Khẩu phần natri được ước tính từ lượng natri bài tiết trong nước tiểu trong 24 giờ. Natri bài tiết trong nước tiểu 24 giờ trung bình là 188,6 ± 57,5 mmol (4,3 g) hay là 10,8 ± 3,3 g muối/ngày. Nam giới có mức bài tiết natri 24 giờ trung bình cao hơn (196,8 ± 56,9 mmol hay 4,5 g) so với nữ giới (181,1 ± 57,4 mmol hay 4,2 g); 97,5% nam giới và nữ giới có mức tiêu thụ muối cao hơn mức khuyến nghị của Tổ chức y tế thế giới là 5 g/ngày. Natri trong gia vị được cho vào trong quá trình nấu hoặc trong khi ăn chiếm tới 81% tổng lượng natri khẩu phần. Thực phẩm chế biến sẵn đóng góp 11,6% và thực phẩm tự nhiên đóng góp 7,4% tổng lượng natri khẩu phần. Riêng về gia vị, phần đóng góp lớn nhất là từ bột canh (35,1% tổng số), nước mắm (31,6%), mì chính 7,4% và muối ăn 6,1%.

Thay thế muối và bột canh thông thường bằng muối và bột canh giảm natri và bổ sung kali có thể đóng góp vào việc giảm khẩu phần natri và huyết áp ở người trưởng thành Việt Nam có tình trạng tiền tăng huyết áp và tăng huyết áp.

Hiệu quả của việc dùng muối và bột canh (một loại gia vị truyền thống phổ biến ở Việt Nam) giảm natri và bổ sung kali tới khẩu phần natri và huyết áp ở người trưởng thành Việt Nam có tiền tăng huyết áp và tăng huyết áp, được nghiên cứu trong một thử nghiêm lâm sàng ngẫu nhiên, mù kép, có đối chứng được trình bày ở ***Chương 5***. Trong quá trình can thiệp, lượng bài tiết natri nước tiểu 24 giờ giảm 52,3 mmol ở nhóm can thiệp và 23,8 mmol ở nhóm chứng, với sự khác biệt về mức độ giảm là 28,5 mmol (1,6 g muối/ngày). Sự thay đổi trung bình về huyết áp ở nhóm can thiệp so với nhóm chứng là -2,6 mmHg (95% CI -4,6 to -0,5, p=0,013) đối với huyết áp tâm thu và -1,6 mmHg (95% CI -3,0 to -0,2, p=0,024) đối với tâm trương. Ngoài ra, việc đảm bảo hàm lượng iốt trong muối và bột canh đã góp phần giảm tỷ lệ thiếu iốt ở cả hai nhóm nghiên cứu (từ 72% xuống 36% ở nhóm chứng và 66% xuống 41% ở nhóm can thiệp).

Tóm lại, tăng huyết áp và tiền tăng huyết áp, là một vấn đề sức khỏe cộng đồng ở Việt Nam. Nhóm người thừa cân và béo phì, nam giới uống quá nhiều rượu, bia, và người dân vùng nông thôn là các nhóm có nguy cơ cao mắc tăng huyết áp trong khi các nhóm có hoạt động thể lực cao hơn, trình độ văn hóa cao hơn thì có nguy cơ mắc thấphơn. Gánh nặng kép về dinh dưỡng tồn tại với sự dịch chuyển từ tình trạng nhẹ cân sang thừa cân ở các nhóm dân cư khác nhau trên toàn quốc, nhưng với mức độ dịch chuyển lớn hơn ở các vùng thành thị so với nông thôn. Hầu hết người dân trong quần thể dân cư (được nghiên cứu) có khẩu phần natri thừa và hầu hết natri trong khẩu phần đến từ natri được cho vào trong quá trình nấu ăn và trong lúc ăn. Do đó, song song với các can thiệp phù hợp để kiểm soát cân nặng và sử dụng đồ uống có cồn và các can thiệp khuyến khích hoạt động thể lực và truyền thông giáo dục dinh dưỡng, giải pháp thay thế muối và gia vị mặn (như bột canh) thông thường với muối và bột canh giảm natri và bổ sung kali có thể là một giải pháp dinh dưỡng cộng đồng hiệu quả nhằm giảm khẩu phần natri và giảm huyết áp cho quần thể dân cư Việt Nam.

Samenvatting (Dutch summary)

De afgelopen decennia zijn de morbiditeits- en mortaliteitspatronen in ontwikkelingslanden sterk veranderd. De prevalentie van infectieziekten is afgenomen, terwijl chronische ziekten juist zijn toegenomen. Er is nu sprake van een 'double burden of disease' ten gevolge van onder- en overvoeding. In 2008 werd geschat dat 75% van alle sterfte in Vietnam veroorzaakt werd door chronische ziekten. Naar schatting 40% was te wijten aan een verhoogde bloeddruk (hypertensie) in de bevolking. Er is daarom dringend behoefte aan inzicht in de onderliggende risicofactoren voor hypertensie zodat geschikte interventies ontwikkeld kunnen worden ter preventie van hart- en vaatziekten in Vietnam.

De onderzoeken beschreven in dit proefschrift hebben als doel de bloeddruk en de determinanten van bloeddruk in een Vietnamese populatie in kaart te brengen. Ook wordt de effectiviteit van een bloeddrukverlagende interventie bestudeerd.

Dit proefscrhift wil antwoord geven op de volgende onderzoeksvragen:

1. Wat is de prevalentie van (pre-)hypertensie en wat zijn risicofactoren voor hypertensie bij volwassenen in de algemene Vietnamese bevolking? (***hoofdstuk 2***)

2. Wat is de trend in de tijd in 'body mass index' (BMI) en wat is de prevalentie van overgewicht en obesitas bij volwassenen in de algemene Vietnamese bevolking? (***hoofdstuk 3***)

3. Hoe hoog is de zoutinname in Vietnam en wat zijn de voornaamste voedingsbronnen van natrium? (***hoofdstuk 3***)

4. Leidt het gebruik van natriumbeperkt en kaliumverrrijkt zout en specerijen tot een lagere natriuminname en een lagere bloeddruk bij Vietnamese volwassenen met (pre-)hypertensie? (***hoofdstuk 5***)

Om de prevalentie van hypertensie en prehypertensie en de risicogroepen voor hypertensie te onderzoeken hebben we gebruik gemaakt van het 'Nationale overgewicht- en obesitasonderzoek' in Vietnam (***hoofdstuk 2***). Om de 'double burden' ten gevolge van wijzigingen in de voeding en de verschuiving van onder- naar overgewicht tussen 2000 en 2005 te onderzoeken werd gebruik gemaakt van de 'Nationale voedselconsumptiepeiling' in Vietnam (***hoofdstuk 3***). De zoutconsumptie en bronnen van natriuminname in het Vietnamese voeding staan in ***hoofdstuk 4*** beschreven. Om het bloeddrukeffect van een natriumbeperkt en kaliumverrijkt zout en een traditionele Vietnamese smaakmaker ('bot canh') op de bloeddruk te bestuderen is een gerandomiseerde, dubbel-blinde trial uitgevoerd (***hoofdstuk 5***). De resultaten, methodologische knelpunten, implicaties voor de volksgezondheid en mogelijkheden voor toekomstig onderzoek worden in ***hoofdstuk 6*** besproken.

Hypertensie en prehypertensie kwamen vaker voor bij Vietnamese mannen met overgewicht en obesitas, bij vrouwen in landelijke gebieden, bij mensen met minder lichamelijke activiteit en bij lager-opgeleide personen.

Hoofdstuk 2 beschrijft zowel de prevalentie van hypertensie en prehypertensie als de risicofactoren voor hypertensie in de volwassen Vietnamese bevolking. De gewogen JNC 7-gedefinieerde[1] prevalentie van hypertensie was 20,7% (95% betrouwbaarheidsinterval (BI): 19,4–22,1) en de prevalentie van prehypertensie was 41,8% (95% BI 40,4–43,1). Hypertensie en prehypertensie kwamen vaker voor bij mannen dan bij vrouwen en kwamen ook vaker voor in landelijke gebieden dan in stedelijke gebieden. Leeftijd, overgewicht, alcoholconsumptie (voor mannen) en het wonen in landelijke gebieden (voor vrouwen) waren onafhankelijk geassocieerd met een hogere prevalentie van hypertensie. Lichamelijke activiteit en opleidingsniveau waren invers geassocieerd met hypertensie. Voor *pre*hypertensie werden directe associaties gevonden met de leeftijd, BMI en het wonen in landelijke gebieden. Binnen de totale groep hypertensieven was 25,9% zich van hypertensie bewust, werd 12,2% ervoor behandeld en had 2,8% de bloeddruk onder controle. Binnen de groep *behandelde* hypertensieven had 32,4% de bloeddruk onder controle.

Tussen 2000 en 2005 nam in Vietnam de prevalentie van personen met overgewicht en obesitas toe terwijl de prevalentie van personen met ondergewicht afnam.

Een hogere BMI, overgewicht en obesitas waren sterk geassocieerd met een toename van het risico op hypertensie (***hoofdstuk 2***). Om deze reden hebben we de trend in de tijd in BMI en de prevalentie van overgewicht (BMI ≥25 kg/m^2) en obesitas (BMI ≥30 kg/m^2) bij Vietnamese volwassenen in de periode 2000-2005 onderzocht (***hoofdstuk 3***). De BMI liet in gehele bevolking en in subgroepen een stijging zien. In 2005 had 6,6% van de bevolking overgewicht en 0,4% had obesitas, bijna het dubbele ten opzichte van 2000 (respectievelijk 3,5% en 0,2%). Wanneer de Zuid-Aziatische BMI-grens van 23 kg/m^2 werd gehanteerd had 16,3% van de bevolking overgewicht in 2005, vergeleken met 11,7% in 2000. Daarentegen was de prevalentie van ondergewicht (BMI <18,5 kg/m^2) in 2005 lager

1 Chobanian AV et al. The seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: The JNC 7 report. JAMA 2003;289:2560-72.

dan in 2000 (20,9% vs. 25,0%). Er waren meer mannen dan vrouwen die ondergewicht of overgewicht hadden, zowel in 2000 als 2005. Personen in stedelijke gebieden hadden een hogere kans op overgewicht en minder kans op ondergewicht dan personen in landelijke gebieden. De verschuiving van ondergewicht naar overgewicht was duidelijker zichtbaar bij personen die meer geld uitgaven aan voedsel.

De inname van natrium was voor het grootste deel van de populatie boven de aanbevolen maximale hoeveelheid. Zoute producten toegevoegd tijdens het koken of aan tafel waren verantwoordelijk voor 81% van de totale natriuminname.

De prevalentie van overgewicht en obesitas was lager in landelijke gebieden dan in stedelijke gebieden. Desondanks was de prevalentie van verhoogde bloeddruk (hypertensie en prehypertensie) hoger in landelijke gebieden. Daarom werden de zoutconsumptie en de bronnen van natriuminname binnen een populatie woonachtig in een landelijk gebied onderzocht. Dit werd gedaan door middel van 24-uurs urineverzamelingen en de 24-uurs gewogen voedselconsumptiemethode (***hoofdstuk 4***). De gemiddelde 24-uurs natriumexcretie was 188,6 ± 57,5 mmol (4,3 g), wat overeenkomt met 10,8 ± 3,3 g zout per dag. Mannen hadden een hogere 24-uurs natriumexcretie (196,8 ± 56,9 mmol, of 4,5 g) dan vrouwen (181,1 ± 57,4 mmol, of 4,2 g). Van de bevoking had 97,5% een natriuminname boven de aanbeveling van de Wereldgezondheidsorganisatie (WHO) van maximaal 5 g per dag. Zoutproducten die toegevoegd werden tijdens het koken of aan tafel waren verantwoordelijk voor 81% van de totale natriuminname. Bewerkte voedingsmiddelen waren verantwoordelijk voor 11,6%, en natuurlijke voedingsmiddelen voor 7,4%. Kruiden en specerijen leverden 35,1%, vissaus 31,6%, mononatriumglutamaat 7,4% en tafelzout 6,1% van de totale natriuminname.

Het vervangen van regulier keukenzout en 'bot canh' door natriumbeperkte en kaliumverrijkte alternatieven kan een relevante bijdrage leveren aan het verlagen van natriuminname en de bloeddruk bij (pre)hypertensieve Vietnamese volwassenen.

De effecten van een natriumbeperkt en kaliumverrijkt zout en 'bot canh' (een traditionele Vietnamese smaakmaker) op de natriuminname en bloeddruk werd in een gerandomiseerde, dubbel-blinde interventiestudie onderzocht (***hoofdstuk 5***). Tijdens de interventie daalde de mediane 24-uurs natriumexcretie met 52,3 mmol in de interventiegroep en met 23,8 mmol in de controlegroep. Dit is een nettoverandering van 28,5 mmol (1,6 g zout) per dag. De gemiddelde bloeddrukverandering in de interventiegroep ten opzichte van de controlegroep was -2,6 mmHg (95% BI -4,6 tot -0,5, p=0,013) systolisch en -1,6 mmHg

(95% BI -3,0 tot -0,2, p=0,024) diastolisch. Daarnaast zorgde de toevoeging van jodium aan het zout en de 'bot canh' voor een significante daling in de prevalentie van jodiumtekort in beide groepen, van 66% naar 41% in de interventiegroep en van 72% naar 36% in de controlegroep.

Conclusie

Een verhoogde bloeddruk of (pre-)hypertensie vormt in Vietnam een belangrijk volksgezondheidsprobleem. Personen met overgewicht en obesitas, mannen die veel alcohol consumeren en personen die in landelijke gebieden wonen zijn de belangrijkste risicogroepen voor een verhoogde bloeddruk. Personen met een hogere lichamelijke activiteit en een hogere opleiding hebben een lager risico op een verhoogde bloeddruk. Er is sprake van een 'double burden', die zich kenmerkt door een verschuiving van ondergewicht en ondervoeding naar overgewicht en overvoeding. Dit geldt met name bij personen in stedelijke gebieden. Het grootste gedeelte van de onderzochte populatie consumeert teveel zout, waarbij het meeste natrium wordt toegevoegd tijdens het koken of aan tafel. Geschikte interventies om lichaamsgewicht en alcoholconsumptie te beperken en lichamelijke activiteit en voedingskennis te stimuleren dienen ontwikkeld te worden in Vietnam. Hierbij kan het vervangen van regulier keukenzout en een smaakmaker als 'bot canh' door natriumbeperkte en kaliumverrijkte alternatieven een waardevolle maatregel zijn om de bloeddruk in de bevolking te verlagen.

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About the author

CURRICULUM VITAE

Do Thi Phuong Ha was born on Aug 12, 1972 in Hanoi, Vietnam. After completing high school, she was admitted to Hanoi University of Medicine in 1989. She graduated as medical doctor in 1995 and started to work at the National Institute of Nutrition of Vietnam as a researcher at the Scientific Management Unit in 1996. She worked as field researcher and supervisor in a randomized controlled trial on the contribution of plant foods to the vitamin A supply of lactating women in Vietnam. During 1998–2000 she took the post graduate course on community nutrition at the SEAMEO-TROPMED regional center for community nutrition at the University of Indonesia, Indonesia. She obtained the degree of Master of Science in Community Nutrition in 2000 with a thesis on physical and cognitive development of early childhood stunted children at school age. From 2000 to 2004 she returned to NIN and was involved in the development of the National strategy for Food fortification in Vietnam 2000–2010 in collaboration with the Micronutrient Initiative and the 10-year Country investment plan for food fortification supported by ADB, working as member of the core group in developing the Regulation and Standards for fortified foods/food fortification. In the period of 2004–2005, she was appointed as Deputy-Chief of Planning Section of NIN, responsible for planning and managing research and development projects/research with international cooperation. She participated in designing and implementing a comprehensive package of interventions for improving maternal and child nutrition in Vietnam supported by UNICEF, and the National survey on Overweight and obesity and related risk factors among Vietnamese adults in 2005. From 2006–2010 she was appointed as Deputy-Head of the department of Community Nutrition, NIN, and continued the work of the National Survey on Adult overweight and obesity, participated in the National survey on Lipid nutrition and Metabolic syndrome in the adults in 2007–2009, in a study on overweight and metabolic syndrome among school children and in other studies on maternal and child nutrition. Since 2010, she has become the Head of the department of Community Nutrition, NIN, working as principle researcher responsible for nutritional epidemiology, food consumption and national food consumption surveys, maternal and child nutrition, and nutrition-related non-communicable diseases. In 2010–2011 she was a member of the core group in developing plan for the prevention and control of overweight-obesity and nutrition-related chronic diseases under the National plan of Action for Nutrition 2011–2015 and the National target project on improving child nutrition 2011–2015. She has provided technical consultation in designing and implementing the pilot community-based intervention on salt reduction lead by the Ministry of Health, including training project staff, developing communication materials and evaluation of the intervention. In 2014, she joined the technical group in developing the National Strategy for the Prevention and Control of Non-communicable diseases in Vietnam in the period of 2015–2025 led by Ministry of Health and the World Health Organization. In 2007 she started her Sandwich PhD program at the Division of Human Nutrition, Wageningen University, the Netherlands, and will defense her thesis on Nov 4, 2014 at the Aula of Wageningen.

PUBLICATIONS

Peer reviewed scientific publications

1. Do Thi Phuong Ha, Johanna M Geleijnse, Le Bach Mai, Frans J Kok, Nguyen Cong Khan, Edith JM Feskens. National prevalence and associated risk factors of hypertension and prehypertension among Vietnamese adults. *American Journal of Hypertension* 2014 [Epub ahead 28/5/204].

2. Do Thi Phuong Ha, Edith JM Feskens, Paul Deurenberg, Le B Mai, Nguyen C Khan, Frans J Kok. Nationwide shifts in the double burden of overweight and underweight in Vietnamese adults in 2000 and 2005: two national nutrition surveys. *BMC Public Health* 2011; 11: 62.

3. Do Thi Phuong Ha, Le Bach Mai, Lai D Truong, Le T Hop, Edith JM Feskens. Sodium intake and its dietary sources in Vietnamese rural adults. (Submitted)

4. Do Thi Phuong Ha, Johanna M Geleijnse, Gerjan J Navis, Frans J Kok, Le Bach Mai, Edith JM Feskens. Low sodium-high potassium condiments reduce sodium intake and blood pressure in Vietnamese adults: a randomized controlled trial. (Submitted)

5. Nguyen Cong Khan, Clive E West, Saskia de Pee, Diane Bosch, Do Thi Phuong Ha, Paul JM Hulshof, Ha Huy Khoi, Han Verhoef, Joseph GAJ Hautvast. The contribution of plant foods to the vitamin A supply of lactating women in Vietnam: a randomized controlled trial. *American Journal of Clinical Nutrition* 2007; 85: 1112-1120.

6. Do Thi Phuong Ha, Le Bach Mai, Nguyen Thi Lam. The association between anthropometric indicators and hypertension and metabolic syndrome in children aged 8-10 years in Hanoi, Vietnam. *Journal of Food and Nutrition Science* 2009; 2(3+4): 62-72.

7. Do Thi Phuong Ha, Nguyen Cong Khan. Early childhood stunting is associated with low physical growth of primary school children. *Journal of Vietnam Medicine* 2002; 269(3): 16-21.

8. Do Thi Phuong Ha, Nguyen Cong Khan. Impaired cognitive performance was associated with early childhood stunting. *Journal of Food and Nutrition Science* 2002; 6(424): 34-36.

Book chapters

1. PMNCH, WHO, World Bank and AHPSR (2014). Success Factors for Women's and Children's Health: Policy and programme highlights from 10 fast-track countries. Geneva: WHO.
2. Le Bach Mai, Do Thi Phuong Ha (2014). Photo album for dietary assessment of children aged 2-5 years [in Vietnamese]. Hanoi: Medical Publishing House.
3. Food and Agriculture Organization, National Institute of Nutrition (2013). Family Nutrition Handbook [in English and Vietnamese].
4. National Institute of Nutrition (2012). Nutritional Epidemiology. Hanoi: Medical Publishing House.
5. Report of 2005 Vietnam National Adult Overweight Survey of the National Institute of Nutrition (2007): Overweight – Obesity and several related factors among Vietnamese adults aged 25-64 years [in Vietnamese]. Hanoi: Medical Publishing House.
6. Do Thi Phuong Ha, Khan Nguyen Cong, Hop Le Thi, Lam Nguyen Thi (2004). Diet, nutrition and prevention of chronic diseases. Vietnamese translated 2003 version of WHO technical report series 916.
7. Do Thi Phuong Ha, Cao Thi Thu Huong, Nguyen Cong Khan, Nguyen Thi Lam (2000). Manila forum 2000: Strategies to fortify essential foods in Asia and the Pacific, ADB, MI, ILSI. Vietnamese translated version.
8. Report of 2000 Vietnam General Nutrition Survey of the National Institute of Nutrition (2003). In Vietnamese. Hanoi: Medical Publishing House.
9. World Health Organization, National Institute of Nutrition, UNICEF (2003). Training course on complementary feeding counselling. Participant's handbook. Vietnamese version.
10. World Health Organization, National Institute of Nutrition, UNICEF (2003). Training course on complementary feeding counselling. Trainer's handbook. Vietnamese version.

OVERVIEW OF COMPLETED TRAINING ACTIVITIES

Graduate School VLAG

The Graduate School

VLAG

Discipline specific activities

Courses

- Regional training course on Anthropometry and stable isotope preparation and administration for body composition assessment, IAEA and Institute of Health and Nutrition, Japan, 2007
- Dietary assessment: Methods, Interpretation and Uses, Mahidol University, Thailanld and UNU/CASNA, 2011
- International training program in "Integrated Marketing Communication for Behavioural Impact (IMC/COMBI) in Health and Social Development", Indiana University, School of Liberal Arts, Indianapolis, USA – WHO – MOH VIETNAM, 2011

Workshops Hanoi, Vietnam

- National Strategy on anaemia prevention throughout life cycle, 2010
- Communication strategy for Cancer prevention in Vietnam, 2010
- Bone density and related factors at the communities in Vietnam, 2011
- Capacity building for preventive health personnel in prevention of non-communicable chronic diseases in Vietnam, 2011
- Development of National Strategy for Nutrition 2011–2020, Vietnam, 2011
- Development of National Plan of Action for Nutrition 2012–2015, Vietnam, 2012
- Iron & folic acid and multi-micronutrient supplementation approaches for anaemia control and prevention in Vietnam, 2012
- Infant and Young Child Nutrition: Addressing Nutritional Problems in Vietnam, 2012
- Development of surveillance indicators of chronic non-communicable diseases for Vietnam, 2013
- Development of training curriculum for bachelor of nutrition and dietetics in Vietnam, 2014
- Development of National strategy for the prevention and control of chronic non-communicable diseases for Vietnam 2015–2010 and vision for 2030, 2014

Meetings

- 35th Annual session of Standing committee for Nutrition, Hanoi, Vietnam, 2007
- Annual Nutrition Scientific Conferences of Vietnam Nutrition Association and National Institute of Nutrition, Hanoi, Vietnam, 2007–2013

- 19th International Congress of Nutrition, Bangkok, Thailand, 2009
- Regional meeting of experts on "Indicators to monitor and measure nutritional improvements" 25–26 September 2012, Bangkok, Thailand held by FAO and Mahidol University, 2012
- Scientific seminar on Soy Health and Trends, Hanoi, Vietnam, 2014
- Consultation workshop on Population approaches on reducing high blood pressure, New York, USA, 2014
- World Health Organization Consultation on Fortification of condiments and seasonings with vitamins and minerals in public health: from proof of concept to scaling up, New York, 2014

General courses

- Information Literacy for PhD held by Library/WUR, Wageningen, 2007
- Course on Teaching methods, National Institute of Nutrition and Hanoi Medical University
- Training workshop on Global health diplomacy, Hanoi, Vietnam, 2012
- Training on the use of Multi-criteria modelling method for selecting interventions under the project "Sustainable Micronutrient Interventions to Control Deficiencies and Improve Nutritional Status and General Health in Asia", Jakarta, Indonesia, 2013.

Optional courses and activities

- Preparation PhD research proposal
- Consultancy on development of pilot intervention model and behaviour-change communication materials on salt reduction in Vietnam, 2013–2014
- HNE course Epidemiology and Public Health, Wageningen, 2007
- HNE course Analytical Epidemiology, Wageningen, 2008
- HNE course Advanced Metabolic Aspects of Nutrition, Wageningen, 2011
- Staff Seminars in Human Nutrition, WUR, 2007, 2008

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