A Survey of Salt Intake, Blood Pressure, and Non-Communicable Disease Risk Factors in Viet Nam

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Abstract

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While numerous epidemiological studies have reported evidence of an association between dietary salt intake and blood pressure, the majority of this evidence has come from developed countries; little is known about the influence of salt consumption in developing countries. Furthermore, in Viet Nam -- a country that has undergone a rapid economic and demographic transition in the past 10-20 years -- nation-wide statistics are scarce, and previous studies attempting to characterize non-communicable disease risk factors were limited by small sample sizes or a limited number of investigated risk factors. Using data from 14,706 participants in a 2009 Viet Nam national survey, this dissertation validates the use of mid-morning spot urine collections as a practical alternative to 24-hour urine collections for estimating salt intake, assesses the association of salt consumption with untreated blood pressure among Vietnamese adults, and presents contemporary, nationally representative prevalence statistics for non-communicable disease (NCD) risk factors among adults in Viet Nam. In 154 participants who provided spot and 24-hour urine collections, we observed a moderate correlation (ρ = 0.34 – 0.35) between spot urine estimated and 24-hour measured salt consumption. Correlations were

higher in women (ρ = 0.39 – 0.40) than in men (ρ = 0.30 – 0.31). In adjusted regression models, we observed no evidence of an association of salt consumption with untreated systolic blood pressure or prevalent hypertension at a national scale in Viet Nam. The associations did not differ in subgroups defined by age, smoking, or alcohol consumption; however, the association of salt consumption with untreated systolic blood pressure was stronger in urban residents than in rural residents (p-value for interaction of urban/rural status with salt consumption, $p = 0.02$). After incorporating sampling and post-stratification weights, the prevalence of NCD risk factors among Vietnamese adults aged 25-65 in 2009 was higher among those living in urban areas than those living in rural areas. The levels of hypertension awareness, treatment, and control were below those seen in other low- and low-middle income countries. Given recent economic and demographic changes, public health interventions should address NCD risk factors that will become more prominent as the population ages.

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Chapter 1. The Validity of Spot Urine Estimated Sodium Excretion in a Viet Nam National Survey

INTRODUCTION

Often used as a gold standard measurement of daily sodium excretion and salt intake, 24-hour urine collections have been shown to be reliable in the setting of small, well-controlled trials, but they are sensitive to collection errors and cumbersome for study participants, inhibiting their application in larger epidemiologic studies and national surveillance efforts.[1-3] For these reasons, accurate estimates of salt consumption in developing countries are lacking, and the contribution of high levels of salt intake to cardiovascular disease incidence in these settings is not well established.

Estimating daily sodium excretion from mid-morning spot urine samples may provide a meaningful alternative to 24-hour urine collections and allow for large-scale studies on the effects of salt consumption in developing countries and resource-limited settings. Easy to collect, spot urine samples typically only require the study subject to fast overnight and to provide only one urine sample, which significantly reduces participation burden compared with 24-hour urine collections. Previous studies have outlined methods for estimating daily sodium excretion from spot urine samples; however, these methods have not yet been externally validated in a resource-limited setting or in a large, population-based epidemiologic study.[4-7] To fill this knowledge gap, we evaluated the validity of estimating daily sodium excretion from spot urine samples that were collected from a subgroup of participants in a 2009 nation-wide survey of non-communicable disease risk factors in Viet Nam.

METHODS

Study Population

The 2009 Viet Nam STEPwise approach to Surveillance (STEPS) survey was a cross-sectional study designed in accordance with World Health Organization (WHO) protocols to estimate the prevalence of key risk factors for non-communicable diseases among Vietnamese adults.[8] A total of 14,706 Vietnamese adults aged 25-64 years old participated in the study. Trained interviewers conducted in-person interviews, and participants were invited to a clinic for a physical exam and blood and spot urine collections. In 2010, a subgroup of 211 individuals from Thai Nguyen province who had participated in the 2009 STEPS survey was selected to participate in an ancillary study examining the validity of spot-urine estimated 24-hour sodium excretion. Participants were excluded if they reported acute or chronic illnesses, pregnancy, an atypical diet during surveying days, or use of antihypertensive medications or medications affecting urinary excretion.

Data Collection

Between November and December 2010, a data collection team consisting of twelve members of the 2009 STEPS survey staff established survey clinics in eight communes within Thai Nguyen, a province in north-east Viet Nam. Clinics were set in a location convenient to participants, such as the Commune People's Committee Office (the local government administration office) or commune health center. The day before their assigned study examinations and urine collections, participants attended an instructional meeting at the study site where they were briefed on the goals of the research and trained on urine collection protocols. The following morning, participants visited the study clinic after overnight fasting. There, they underwent a physical examination and an interviewer-administered questionnaire, after which spot urine samples were collected and bladders completely emptied. Participants were then instructed to return to their regular daily activities, to avoid unusual activities that would result in excessive perspiration, to collect every drop of urine in the supplied container, and to return at the same time the next day to complete their 24-hour urine collections. When they returned the following morning, each participant completed their 24-hour collections by completely emptying their bladders at their individual 24-hour time mark.

Urine was collected and stored in standard containers, and was immediately transported to freezers at the Viet Nam National Institute of Nutrition where they were kept at a temperature of -20 degrees Celsius. Sodium and creatinine concentrations were measured using an Ion Selective Electrode method. Total sodium excretion in the 24-hour collections was calculated by multiplying the sodium concentration by the volume of the urine sample.

Participants were assumed to have kidney function that was in steady state. Daily sodium excretion was estimated from spot urine samples using the following formulas:

Tanaka[7]: $eNa = 21.98 \times \{(Na_S/Cr_S) \times Pr.Cr_{24}\}^{0.392}$

Kawasaki[4]: $eNa = 16.3 \times \{(Na_S/Cr_S) \times Pr.Cr_{24}\}^{0.5}$

eNa: Estimated 24-hour sodium excretion (mmol/day)

Na_S: Sodium concentration in spot urine (mEq/L)

Cr_S: Creatinine concentration in spot urine (mg/L)

$Pr.Cr_{24}$: estimated 24hr urinary Cr excretion (mg/day)

$$Pr.Cr_{24} = - 2.04 \times Age + 14.89 \times Body\ weight\ (kg) + 16.14 \times Height\ (cm) - 2244.45$$

Statistical Analysis

The agreement between spot urine estimated from daily sodium excretion and 24-hour measured sodium excretion was assessed using Pearson correlation coefficients. We used a misclassification matrix to evaluate the degree to which spot urine derived estimates correctly identify quartiles of daily sodium excretion. We also evaluated the influence of different sex-specific creatinine prediction formulas on the validity of spot-urine estimated daily sodium excretion.[1,7,9]

Because 24-hour urinary sodium and creatinine concentrations are highly sensitive to collection error, we excluded participants with 24-hour creatinine to body weight ratios that exceeded two standard deviations of the mean. Moreover, these levels were biologically implausible (creatinine (mg/dL) to weight (kg) ratio: <8 or >38).[4,6,10]

Of the 211 participants of the 2009 Viet Nam STEPS survey from Thai Nguyen province who were selected to participate in the study, 154 (73%) met the inclusion criteria and participated in spot and 24-hour urine collections. Eight participants were excluded from the analyses because of biologically implausible 24-hour creatinine measurements relative to their body weight, leaving data from 146 participants available for analysis.

RESULTS

Characteristics of the 66 male and 80 female participants included in the study are reported in **Table 1.1**. The average age of participants was 44 years. Women were shorter, lighter, and less likely to have a history of smoking than men. The average amount of sodium excreted in 24-hour urine collections was 188 mmol, equivalent to an intake of 11 grams of salt (17.1 mmol sodium = 1g table salt (sodium chloride)).

Daily sodium excretion values, measured from 24-hour urine collections and estimated from spot urine samples using the Tanaka and Kawasaki formulas, and their correlation with values from 24-hour urine collections are presented in **Table 1.2** and **Figures 1.1** and **1.2.** Spot urine based estimates were more strongly correlated with 24-hour urine measurements in women than in men. On average, the Tanaka method results in underestimated daily sodium excretion and the Kawasaki method results in over-estimates; however, the overall degree of correlation with 24-hour urine measured sodium excretion was similar in the two methods (Tanaka $\rho = 0.35$, Kawasaki $\rho = 0.34$). Use of alternate sex-specific formulas to predict daily creatinine excretion did not alter these findings.[1,9]

Tables 1.3 and 1.**4** present the agreement between quartiles of spot urine estimated and 24-hour urine measured sodium excretion using the Tanaka and Kawasaki formulas. Tanaka derived estimates correctly predicted quartile of sodium excretion for 32% of measurements, while underestimating 42% and overestimating 26%. Kawasaki derived estimates correctly, over-, and under-estimated 31%, 20%, and 49% of measurements, respectively. Of the 143 participants with a measured sodium intake of ≥100mmol per day, Tanaka derived estimates identified 141, and Kawasaki derived estimates identified 143.

DISCUSSION

Our findings show a moderate correlation between fasting spot urine based estimates of daily sodium excretion and measurements drawn from 24-hour urine collections. Correlations were stronger among women than men, and on average, the Tanaka formula underestimated daily sodium excretion while the Kawasaki formula overestimated daily sodium excretion.

While Tanaka et al. tested their equation on an external population of 336 Japanese workers, to the best of our knowledge, no other studies have attempted to validate either of these formulas on external populations.[7,11] The degree of correlation that we observed in our population, ($\rho = 0.35$), was similar to that observed by Tanaka to their external population ($\rho = 0.32$). The use of spot urine to estimate 24-hour sodium excretion compares favorably with other methods that are commonly used in nutrition studies to estimate salt consumption, including food frequency questionnaires, which are marked by a low degree of correlation ($\rho < 0.15$).[12-14]

Our study was conducted among a Vietnamese population with a high level of salt consumption; the observed average salt intake was eleven grams per day, which is well in excess of the World Health Organization's recommendation of less than five grams per day.[15] Although the Tanaka formula misclassified fewer of those with low sodium excretion than the Kawasaki formula, caution should be taken when applying either of these formulas to other populations, as our findings may not be generalizable to populations with lower salt consumption levels.

It is possible that women in our study adhered to the study protocol more closely than men, and that their resulting 24-hour urine collections were more complete and accurate than their male counterparts, resulting in a higher degree of correlation. While some sodium is excreted through perspiration, that amount is relatively small (10-70mmol/L), and women in Viet Nam are active participants in agriculture and would not sweat substantially less than men.[16] On average, women produce less creatinine per day than men, and the creatinine prediction formula we used does not take sex into account. However, the use of sex-specific creatinine prediction formulas did not alter our findings.[9,11]

It is likely that we have underestimated the true correlation between spot urine estimated and 24-hour urine measured sodium excretion. Because urinary sodium concentrations fluctuate from day-to-day and hour-to-hour, correlations between spot urine estimates and 24-hour urine measurements may be affected by intra-individual variation in urinary sodium concentration. However, because the spot urine samples were collected immediately prior to the start of the 24-hour urine collections, and because the spot urine collections were taken at the same time of day for each of the study participants, any resulting misclassification should be small and nondifferential.

To estimate daily sodium excretion from a spot urine sample (in the absence of a 24-hour urine collection), it is necessary to predict an individual's daily creatinine excretion. Participants with more skeletal muscle mass produce more creatinine than average, and conversely, participants with less muscle mass produce less creatinine than average.[17] While creatinine prediction formulas incorporate both height and weight terms, body mass index is not always an accurate indicator of muscle mass.[18] As a result, daily sodium estimates for participants with particularly high or low muscle mass may be less accurate than for those with average muscle mass.

Recent guidelines, established by the WHO in 2012 and the Institute of Medicine in 2013, suggest that, among individuals consuming more than 85-100mmol of sodium per day, sodium reduction is associated with reduced risk of cardiovascular disease and death.[15,19] In our study population, 144/146 participants consumed more than 100mmol of sodium, and spot urines correctly identified a high proportion of these participants (sensitivity: Tanaka = 98%, Kawasaki = 100%; positive predictive value: Tanaka: 98%, Kawasaki: 98%). Given such a high sensitivity and positive predictive value, spot urine collections may serve as a useful component of national surveillance programs to identify populations that would benefit from reduced sodium intake.

CONCLUSIONS

Our study validated the utility of spot urine tests in an international setting. Spot urine samples may provide a useful tool for researchers investigating salt consumption and for identifying targets for salt reduction interventions in settings where 24-hour urine collections are not feasible.

Chapter 2. The Association of Estimated Salt Intake with Blood Pressure in a Viet Nam National Survey

INTRODUCTION

While numerous epidemiological studies have reported evidence of an association between dietary salt intake and blood pressure, the majority of this evidence has come from developed countries.[20-22] Few studies on this topic have been conducted in developing countries, and those studies were focused on unique, geographically isolated populations with low salt consumption.[21,23-25] The impact of salt on blood pressure in developing countries with a high level of salt intake, such as those of South-east Asia, is unclear.[26,27]

Viet Nam has undergone a period of rapid economic growth in the past 10-20 years, during which the country also experienced substantial rural to urban migration, increased tobacco use, the adoption of unhealthier diets, and decreased levels of physical activity.[27-31] These changes align with the "epidemiological transition," the concept that as countries become more developed, the burden of disease shifts to chronic non-communicable diseases as the number of deaths from communicable diseases decreases and the average life expectancy increases.[32] Evidence from urban areas strongly suggests that the Vietnamese urban population is growing older and more obese, and that the prevalence of hypertension and diabetes is on the rise.[30,31,33,34]

As a modifiable risk factor, salt consumption may be an appropriate target for public health interventions to lower population-wide blood pressure, which is hypothesized to lead to major improvements in public health.[20,22,35,36] Although the cost of antihypertensive medications for an individual can be as little as pennies a day, salt reduction interventions are the most cost-effective means by which to lower population-wide blood pressure.[35,37-39] Before any nation-wide salt reduction efforts are considered in Viet Nam, it is important to understand whether the effect of salt on blood pressure among Vietnamese is similar to that previously observed in developed countries.

Salt consumption is notoriously difficult to measure accurately, which has inhibited its investigation in resource-limited settings and developing countries.[1,22,40] However, recent research has shown that a single spot urine collection can be used to reliably estimate salt intake in settings where 24-hour urine collection is not feasible.[4,7,41] We used spot urine sample data from a nationally representative population in Viet Nam to evaluate the association of salt intake with untreated blood pressure and prevalent hypertension. We also assessed whether this association differed by age, smoking, alcohol consumption, or rural/urban residence.

METHODS

Study Population

The 2009 Viet Nam STEPwise approach to Surveillance (STEPS) survey is a cross-sectional study designed in accordance with World Health Organization protocols to estimate the prevalence of key risk factors for non-communicable diseases among Vietnamese adults.[8] A nationally representative sample of 22,940 individuals 25-64 years of age was selected for inclusion in the study. Between June and October 2009, trained interviewers conducted in-person interviews, and participants were invited to a clinic for a physical exam and blood and urine collection. A total of 14,706 Vietnamese adults completed an interview, physical examination, and blood collection; a spot urine sample was collected from a subsample of 2,551 participants. Participants were excluded if they reported acute illnesses or pregnancy, or if they reported current use of antihypertensive medications.

Data Collection

Each province recruited a data collection team of approximately 20 local medical personnel. Survey clinics were set up at each commune in a location convenient to participants, such as the People's Committee Office (the local government administration office) or health center. The times that clinics opened were adjusted for each area based on the activities of local participants, and varied between 6 and 7AM. Participants attended the clinic after overnight fasting.

Urine and blood samples were collected before participants ate breakfast. Samples were collected in standard containers, and were refrigerated as they were transported to the Viet Nam National Institute of Nutrition, where they were kept at -20 degrees Celsius. The concentrations of sodium and creatinine in the urine were measured using an ion selective electrode method. Fasting blood glucose and total cholesterol were measured from capillary whole blood using Roche Diagnostics Accutrend Plus glucometers.

At the clinic visit, participants were administered an in-person questionnaire by a study interviewer. The questionnaire was adapted from the WHO STEPS instrument (version 2.1) that was translated into Vietnamese.[8] Topics covered included demographic information, tobacco and alcohol use, physical activity, and medical history (self-reported history of hypertension, diabetes, and medication use).

Physical measurements were taken with the participant in bare feet without headwear or heavy clothing. Blood pressure was measured using digital automatic blood pressure monitors after the participants had rested for at least 15 minutes. Two blood pressure measurements were taken; if they differed by more than 25/15mmHg then a third measurement was taken. The average of the last two blood pressure measurements was used in the analysis.

Statistical Methods

Daily salt consumption was estimated from a fasting, mid-morning spot urine sample using a formula derived by Tanaka:[7]

$$eNa = 21.98 \times \{(Na_S/Cr_S) \times Pr.Cr_{24}\}^{0.392}$$

eNa: Estimated 24-hour sodium excretion (mmol/day)

Na_S: Sodium concentration in spot urine (mEq/L)

Cr_S: Creatinine concentration in spot urine (mg/L)

$Pr.Cr_{24}$: estimated 24hr urinary Cr excretion (mg/day)

$$Pr.Cr_{24} = - 2.04 \times Age + 14.89 \times Body\ weight\ (kg) + 16.14 \times Height\ (cm) - 2244.45$$

A validation substudy in 146 participants of this study comparing spot urine collection with 24-hour urine collection indicated that the spot urine samples provide a valid estimate of daily salt consumption (ρ = 0.35).[41] In a sensitivity analysis, we used an alternate formula that has similar validity (ρ = 0.34), but yields higher estimated daily salt consumption than the Tanaka method in this population.[4,41] Results are presented in terms of grams of salt intake (1 gram salt (sodium chloride) = 17.1mmol sodium). We excluded participants with extreme estimated salt consumption levels (less than 3 or more than 17 grams of salt per day), as these are outside the expected ranges for salt consumption observed in previous international studies.[21]

Associations of daily salt consumption with untreated systolic blood pressure were assessed using adjusted linear regression models. Relative risk regression was used to directly estimate the relative risk of hypertension associated with daily salt consumption, using generalized linear models with a Poisson distribution and robust standard errors.[42] Models included adjustment terms for age, sex, height, weight, smoking, total cholesterol, diabetes, and physical inactivity. Prevalent hypertension was defined as systolic blood pressure ≥140mmHg or diastolic blood pressure ≥90mmHg, and diabetes was defined as fasting glucose ≥126mg/dL or use of diabetes medication in the previous two weeks. Smoking was defined as current or not current use of tobacco; alcohol use was defined as five or more alcoholic drinks per week. Physical inactivity was defined as not meeting any of the following three criteria: 30 minutes of moderate-intensity physical activity on at least 5 days every week, 20 minutes of vigorous-intensity physical activity on at least 3 days every week, or a combination of vigorous- and moderate-intensity physical activity that exceeds 600 metabolic equivalent (MET)-minutes per week.[43] Rural and urban classification was based on the commune's rural/urban designation in the 2009 national census.

To evaluate differences in the association of salt intake with untreated blood pressure and prevalent hypertension by age (<45 years vs. ≥45 years), smoking (non-current vs. current), alcohol use (<5 drinks/week vs. ≥5 drinks/week), and rural/urban status, we tested interaction terms between salt intake and each of these risk factors in separate models. Interaction models included the primary set of adjustment covariates, except the age interaction model, which did not include a continuous term for age. Interaction models for smoking and alcohol consumption models were restricted to men due to the infrequency of smoking (2%) and alcohol use (<1%) among women.

Analyses were conducted with STATA version 11.2 using the *svy* procedure. All analyses used STEPS sample weights that adjust for non-coverage and unequal probabilities of selection; sample weights incorporated post-stratification weights, which were calculated for each age (25-34, 35-44, 45-54, and 55-65 years) and sex stratum within each province using data from the 2009 Viet Nam national census.[44] Standard errors were computed using a robust variance estimator to take into account the complex sample design.

Of the 2,551 participants who provided spot urine samples, 7 were pregnant, 133 reported use of antihypertensive medications in the previous two weeks, 54 had missing body size or blood pressure measurements, and 24 had implausible salt intake levels and were excluded, leaving data from 2,333 participants available for analysis.

RESULTS

Characteristics of the 1083 male and 1250 female participants in the study are reported in **Table 2.1**. The average age of participants was 37 years. On average, women were shorter, lighter, had lower blood pressure, and were less likely to smoke or drink alcohol than men. Participants consumed an average of 9.9 grams of salt per day, the distribution of which was relatively normal (**Figure 2.1**).

In sex-stratified models adjusted for age, height, weight, smoking, total cholesterol, diabetes, and physical inactivity, there was no evidence of an association of salt consumption with systolic blood pressure or prevalent hypertension (**Table 2.2**).

There was no evidence of a difference in the association of salt consumption with untreated systolic blood pressure or prevalent hypertension in subgroups defined by age, smoking, alcohol consumption, or urban/rural residence (**Table 2.3**). However, the association of salt consumption with untreated systolic blood pressure was stronger in urban participants than in rural participants (p-value for interaction of urban/rural status with salt consumption, $p = 0.02$). While the mean systolic blood pressure was similar in urban and rural participants (119 vs. 118 mmHg, $p = 0.79$), salt consumption levels were slightly lower in urban residents than in rural residents (9.5 vs 10.1 g/day, $p = 0.01$). Neither restricting analyses to Kinh participants nor use of the Kawasaki formula to estimate salt intake altered any of these findings.

DISCUSSION

We observed that salt consumption was not associated with untreated systolic blood pressure or the risk of prevalent hypertension at a national level in Viet Nam. However, our results suggest that salt consumption has a stronger association with untreated systolic blood pressure in urban residents than in rural residents in Viet Nam.

To the best of our knowledge, this is the first study to examine the association of salt consumption with blood pressure at a national level in South-east Asia.[22,26,27] Our finding of no association of salt consumption with blood pressure at a national level contrasts with a recent meta-analysis of thirty-four trials in developed countries, which observed a positive association of salt intake with blood pressure (difference in systolic blood pressure per one-gram higher level of salt consumption; $\beta = 0.95$, 95%CI: 0.72, 1.18).[20] We did not observe the differential association of salt consumption with systolic blood pressure or hypertension by smoking status, alcohol consumption, or age that has been observed elsewhere.[21]

Reasons that salt consumption may have a greater impact on the blood pressure of urban participants than of rural participants are not clear. The varying degree to which an individual's blood pressure responds to changes in salt intake ("salt-sensitivity") is largely driven by renal function.[45] A number of genetic factors have been found to impair renal function and are associated with salt-sensitivity.[46-49] Both rural and urban residents were predominantly Kinh ethnicity (98% and 96%, respectively; $p = 0.23$), and restricting analyses to Kinh participants did not alter our findings. Given that the rate of rural to urban migration from 1999 to 2010 increased by an average of 9.2% per year, and one-sixth of the urban population in 2009 had moved from rural areas in the past five years,[50] it would seem unlikely that genetic differences between rural and urban participants fully explain the stronger association of salt consumption with blood pressure in urban residents.

Apart from genetics, a number of other factors are associated with salt-sensitivity, including old age and diets low in potassium or calcium. [45,46,51-53] While we were able to adjust for age as a confounding variable, we were not able to adjust for dietary potassium or calcium, or for markers of renal function, as they were not measured in this survey. If these factors were more common among urban participants than rural participants, they could impair renal function (thereby increasing the salt-sensitivity) of urban residents more than rural residents, which could help explain the differential association of salt consumption with blood pressure by urban/rural status that we observed.

It is also possible that because rural participants were more likely to work in agriculture, they would lose more salt in sweat than urban participants due to the physical nature of their work and the hot climate of Viet Nam. Although there is a common perception that extra salt should be consumed to replace electrolytes lost due to perspiration, the amount of salt needed to maintain electrolyte balance in most conditions is actually quite low (approximately 0.6 – 1.2 grams per day for an average adult), so the amount consumed in this population far exceeded physiological need.[22,54,55] While some sodium is indeed secreted through perspiration, the amount is relatively small (0.6 - 4.1 grams per liter of sweat), with heat acclimated people on the low end of that spectrum.[1] Because the study population would be well acclimated to the heat and humidity, and because we adjusted for physical activity in our analyses, we do not have reason to believe that differential perspiration loss by rural/urban status influenced our findings.

Although many studies have documented a rise in blood pressure corresponding with rural to urban migration, few have examined the influence of salt on this association.[56,57] A 1991 study of the Yi, an ethnic minority in southwestern China, collected blood pressure measurements and 24-hour urine samples from Yi farmers who lived in the rural mountains and Yi who had migrated to nearby urban centers.[23] Rural Yi farmers had low levels of salt consumption (5.6g/day) and one of the lowest average blood pressures in the world (98/60mmHg); both of which were lower than those of Yi urban migrants (9.3g/day, 107/69mmHg).[21] The study authors concluded that, due to the ethnic similarity of the urban migrants to the rural farmers, the higher blood pressure observed in the urban migrants was largely due lifestyle changes, including increased salt intake. A 1984 study of Kenyan rural to urban migrants provided similar findings.[24] In our population, rural participants had a slightly higher average level of salt consumption than urban participants, but the mean systolic blood pressure was similar in the two groups.

The cross-sectional nature of the study is a limitation of this analysis. Because we cannot assess whether salt consumption levels predated systolic blood pressure levels, we are only able to assess the correlation of salt consumption with blood pressure and prevalent hypertension, rather than causality. Another limitation is our use of an imperfect measure of salt consumption. Although 24-hour urine collection is the gold standard for estimating salt consumption in epidemiological studies, spot urine sample-derived estimates have been shown to provide valid estimates in this population, with a correlation coefficient (ρ) = 0.35.[41] Assuming that any misclassification was non-differential, use of spot urine estimated salt consumption may have impaired our ability to detect associations of salt consumption with blood pressure and hypertension, resulting in conservative estimates of the association of salt consumption with untreated blood pressure and prevalent hypertension.[58]

CONCLUSIONS

There was no evidence of an association of salt consumption with elevated systolic blood pressure at a national level in Viet Nam; however, higher salt consumption is more strongly associated with higher untreated blood pressure in urban residents than in rural residents. The reasons for this differential association are not clear, and given the large rate of rural to urban migration experienced in Viet Nam, this area warrants further investigation.

Chapter 3. The Prevalence of Non-Communicable Disease Risk Factors in a 2009 Viet Nam National Survey

Introduction

Over the past 10-20 years, Viet Nam has undergone a rapid transition from a planned, agriculture based economy towards a free-market economy, resulting in a substantial change of the country's economic and demographic landscape [28,29,59,60]. Historically a predominately rural country, rural to urban migration has increased by 9.2% per year since 1999, and over 30% of Vietnam's 90 million citizens now live in urban areas.[50,61] Reports indicate that increased economic development has also coincided with an increase in tobacco use, the adoption of unhealthier diets, and decreased levels of physical activity.[27-31 33,34] These changes align with the "epidemiological transition," the concept that as countries become more developed, the burden of disease shifts to chronic non-communicable diseases as the number of deaths from communicable diseases decreases and the average life expectancy increases.[32]

While a few studies during this period of development and transition have reported on the current state of non-communicable disease risk factors in Viet Nam, these studies either examined a limited set of risk factors or were restricted to specific geographic regions and populations; an accurate assessment of the scope of non-communicable disease risk factors across the entire nation has been lacking.[30,60,62-64] The goal of this study was to present contemporary, nationally representative prevalence statistics for non-communicable disease risk factors among Vietnamese adults using data from a large national survey conducted in 2009.

METHODS

Study Population

The 2009 Viet Nam STEPwise approach to Surveillance (STEPS) survey was a national cross-sectional study designed in accordance with World Health Organization protocols to estimate the prevalence of key risk factors for non-communicable diseases among Vietnamese adults.[8] Probability proportional to size (PPS) sampling was used to select a nationally representative sample of 22,940 individuals aged 25-64 years from eight provinces, with each province representing a unique ecological region within Viet Nam (**Figure 3.1**).

Between June and October 2009, trained interviewers conducted in-person interviews, and participants were invited to a clinic for a physical exam and blood sample collection, urine samples were collected from a subset of participants. Of the 22,940 Vietnamese adults selected to participate, 14,706 (64%) completed an interview, physical examination, and blood collection; a spot urine sample was collected from 2,551 participants. Fifty-two women reported pregnancy at the time of the study exam and were excluded, leaving 14,654 participants eligible for analyses.

Data Collection

Each province recruited a data collection team of approximately 20 local medical personnel. Survey clinics were set up at each commune in a location convenient to participants, such as the

People's Committee Office (the local government administration office) or health center. The times that clinics opened were adjusted for each area based on the activities of local participants, and varied between 6 and 7AM. Participants were instructed to attend the clinic after overnight fasting.

At the clinic visit, participants were administered an in-person questionnaire by a study interviewer. The questionnaire was adapted from the WHO STEPS instrument (version 2.1) that was translated into Vietnamese.[8] Topics covered included demographic information, tobacco and alcohol use, physical activity, and medical history (self-reported history of hypertension, diabetes, and medication use).

Physical measurements were taken with the participant in bare feet without headwear or heavy clothing using portable electronic stadiometers and scales, which were checked and calibrated every week. Waist circumference was measured using a constant tension tape measure at the narrowest point between the costal border and the iliac crest at the mid-axillary line. Blood pressure was measured using digital automatic blood pressure monitors after the participants had rested for at least 15 minutes. Two blood pressure measurements were taken; if they differed by more than 25/15mmHg then a third measurement was taken. The average of the last two blood pressure measurements was used in the analysis.

Blood and urine samples were collected before participants ate breakfast. Samples were collected in standard containers, and were refrigerated as they were transported to the Viet Nam National Institute of Nutrition, where they were kept at -20 degrees Celsius. Fasting blood glucose and total cholesterol were measured from capillary whole blood using Roche Diagnostics Accutrend Plus glucometers. The concentrations of sodium and creatinine in the urine were measured using an ion selective electrode method.

Statistical Methods

Age- and sex- specific prevalence was calculated as the number of prevalent cases divided by the total number of participants at risk. Associations of rural/urban residence with prevalent hypertension, diabetes, high cholesterol, overweight, physical inactivity, current smoking, and regular alcohol consumption were assessed using age- and sex-adjusted generalized linear models with a Poisson distribution and robust standard errors.[42] Participants who did not arrive at the clinic in a fasting state (3%, N=481) were excluded from analyses of biochemical measures.

Prevalent hypertension was defined as systolic blood pressure ≥140mmHg, diastolic blood pressure ≥90mmHg, or self-reported use of antihypertensive medications in the previous two weeks. Diabetes was defined as fasting glucose ≥6.9mmol/L or self-reported use of insulin or other diabetic medications in the previous two weeks. High cholesterol was defined as ≥6.2 mmol/L. Daily salt consumption was estimated from a fasting, mid-morning spot urine sample using a formula derived by Tanaka;[7] a validation substudy in 146 participants of this study comparing spot urine collection with 24-hour urine collection indicated that the spot urine samples provide a valid estimate of daily salt consumption (correlation coefficient = 0.35).[41] Physical inactivity was defined as not meeting any of the following three criteria on the physical activity questionnaire: 30 minutes of moderate-intensity physical activity on at least 5 days every week, 20 minutes of vigorous-intensity physical activity on at least 3 days every week, or a combination of vigorous- and moderate-intensity physical activity that exceeds 600 metabolic equivalent (MET)-minutes per week.[43] Rural and urban classification was based on the commune's rural/urban designation in the 2009 national census.

In regression models, smoking was defined as current (vs. not current) smoking, and regular alcohol use was defined as consuming alcohol five or more days per week (vs. less than five days per week). Because Asian populations have shown a higher body fat composition at lower BMI thresholds than Western populations, we evaluated overweight status using both international (BMI ≥ 25) and Asian-specific (BMI ≥ 23) definitions.[65,66]

Hypertension and diabetes awareness were each defined as having a self-reported history of hypertension or diabetes. Hypertension treatment was defined as use of antihypertensive medications in the previous two weeks; diabetes treatment was defined as use of insulin or other diabetic medications in the previous two weeks. Hypertension control was defined as systolic and diastolic blood pressure $<140/90$mmHg with concurrent use of antihypertensive medications.

To ensure that descriptive results were nationally representative, statistics were weighted according to the sampling weight for each individual. Sampling weights incorporated PPS and post-stratification weights; post-stratification weights were calculated for each age and sex stratum within each province using data from the 2009 Viet Nam national census.[44] As a sensitivity analysis, we repeated the analyses using only the PPS weights, and compared the results to those using both the PPS and post-stratification weights. Estimations were conducted using the SVY package in STATA (v11.2).

RESULTS

Physical, behavioral, and demographic characteristics of the 7850 female and 6804 male participants, weighted to represent the national population of Viet Nam between the ages of 25 and 65, are presented in **Table 3.1**. Men had a higher average systolic and diastolic blood pressure than women (systolic: 122 vs. 113mmHg, diastolic: 74 vs. 60mmHg, respectively). Smoking and alcohol consumption were common among men (73% ever smokers, 38% at least one drink per week), but almost nonexistent among women (98% never smokers, 98% drank less than once per week). Use of chewing tobacco was uncommon in both sexes (1% among men, <1% among women). The study population was predominately of Kinh ethnicity (97%). The estimated mean level of salt consumption was 10 grams per day, and 99% of the population exceeded the WHO recommended limit of 5 grams of salt per day.[15]

We estimate that in 2009, 12% of the Vietnamese population between the ages of 25 and 65 had prevalent hypertension, 1.4% had prevalent diabetes, 4% had a total cholesterol of 6.2mmol/L or higher, 28% had a BMI of 23 or higher, 13% had a BMI of 25 or higher, and 36% were physically inactive. Age-specific prevalence of non-communicable disease risk factors for women and men are presented in **Figures 3.2a-b**. Hypertension prevalence increased with age in both sexes, and was higher among men than women ($p<0.01$). Women were more likely than men to be overweight and/or physically inactive ($p<0.01$).

Age-specific prevalence for men and women, further stratified by rural and urban residence, is presented in **Figures 3.3a-d**. In age- and sex-adjusted models, urban residence was associated with an increased risk of prevalent diabetes (RR = 1.96, 95%CI: 1.58 – 2.44), high cholesterol (RR = 2.20, 95%CI: 1.91 – 2.55), and physical inactivity (RR = 2.12, 95%CI: 2.00 – 2.26), but not prevalent hypertension (RR = 1.01, 95%CI: 0.95 – 1.08).

Of the 12% of the population with prevalent hypertension, 35% were aware of their hypertensive status, and 21% had used antihypertensive medications in the previous two weeks; 27% percent of those receiving antihypertensive medications had blood pressure below 140/90mmHg (**Table 3.2**). Urban residents were more likely to be aware of their hypertensive status and to have taken antihypertensive medications than rural residents ($p < 0.01$). Of the 1.4% of the population with prevalent diabetes, 41% were aware of their diabetic status, 36% were receiving treatment, and 25% had fasting glucose <6.9mmol/L. Awareness, treatment, and control of diabetes did not differ by rural/urban residence.

The application of post-stratification weights lowered the mean age of the study population from 41 years to 37 years (**Table 3.3**). This demographic shift resulted in lowered national prevalence estimates among 25-65 year olds for hypertension, diabetes, and high cholesterol, and higher prevalence estimates for physical inactivity and overweight.

DISCUSSION

Findings from this study confirm that Vietnamese men and women living in urban areas were more likely to be overweight and/or have prevalent diabetes and high cholesterol than Vietnamese men and women living in rural areas. They were also more likely to be aware of and have received treatment for prevalent hypertension. Smoking was common among men, and more than one third of Vietnamese adults were physically inactive, though physical inactivity was more frequent among younger than older Vietnamese.

Our findings add to the growing body of evidence that suggest that hypertension awareness, treatment and control in Viet Nam is below levels seen in other low- and low-middle income countries.[60,63,67,68] Our age-specific hypertension prevalence estimates were similar to those seen in recent studies in Viet Nam by Son, Minh, and Nguyen, although we did not observe the higher prevalence of hypertension among urban residents that was observed by Son.[60,62,63] These age- and sex-specific rates were also similar to what has previously been reported from China, India, and other Asian countries.[69]

Although we observed a low prevalence of diabetes (1.4%) relative to global averages (2.8%), given the low level of diabetes awareness, the high prevalence of obesity, the high level of inactivity -- particularly among young urban men and women -- and the high prevalence of smoking among men, it is likely that diabetes will be a growing concern as the younger Vietnamese generations age.[70]

While it is well understood that levels of physical activity generally decline with age, by contrast, we observed lower levels of physical activity among younger adults than among older adults.[71] We also observed a higher level of inactivity among urban residents than in rural residents (45% vs. 31%), which is similar in magnitude to the difference in physical inactivity seen between lower-middle income countries and upper-middle income countries (25% vs. 45%).[43]

The proportion of the population who were overweight was higher than previously reported estimates in Viet Nam, but less than has been observed in other East and South-East Asian countries.[72,73] Information regarding total cholesterol levels in lower-middle income countries is limited; however, the prevalence of high cholesterol we observed among Vietnamese adults (4%) appears to be well below what has been reported in lower-middle income countries (28% in Thailand, 30% in Jordan).[74]

With a median age of 28 years, Vietnam is a predominately young country.[44] Because younger sampled persons were less likely to participate in this survey than older sampled participants, and because they constitute a majority of the population, post-stratification shifted the population average age from 41 years to 37 years. As a result, this correction had a marked influence on prevalence estimates that are strongly associated with age, and the national prevalence estimates for hypertension, diabetes, and high cholesterol lowered, while the prevalence estimates for overweight and physical inactivity increased.

Strengths of this study include the large number of study participants, which enabled age-, sex-, and rural/urban-specific comparisons, and the use of standardized instruments for data collection. The upper age limit of 65 years was a limitation of our study; because many non-communicable disease risk factors are strongly associated with age, we were not able to estimate the prevalence for those individuals at highest risk. As a result, our national prevalence estimates are more conservative than if people aged 65 and up were included; however, we present age-specific prevalence. Because participants were drawn from eight provinces, certain ethnic groups may have been under- or over-represented based on their geographic concentrations. In particular, Kinh participants (who account for 86% of the national population) were overrepresented in this sample. Thus, further study of NCDs in ethnic minorities in Viet Nam is needed.

CONCLUSIONS

Vietnamese adults living in urban areas have a higher prevalence of many NCD risk factors than those living in rural areas, smoking is particularly common among men, and the level of hypertension treatment and awareness is below what is seen in other low- and low-middle income countries. Given recent economic and demographic changes, public health interventions should address NCD risk factors that will only become more prominent as the population ages.

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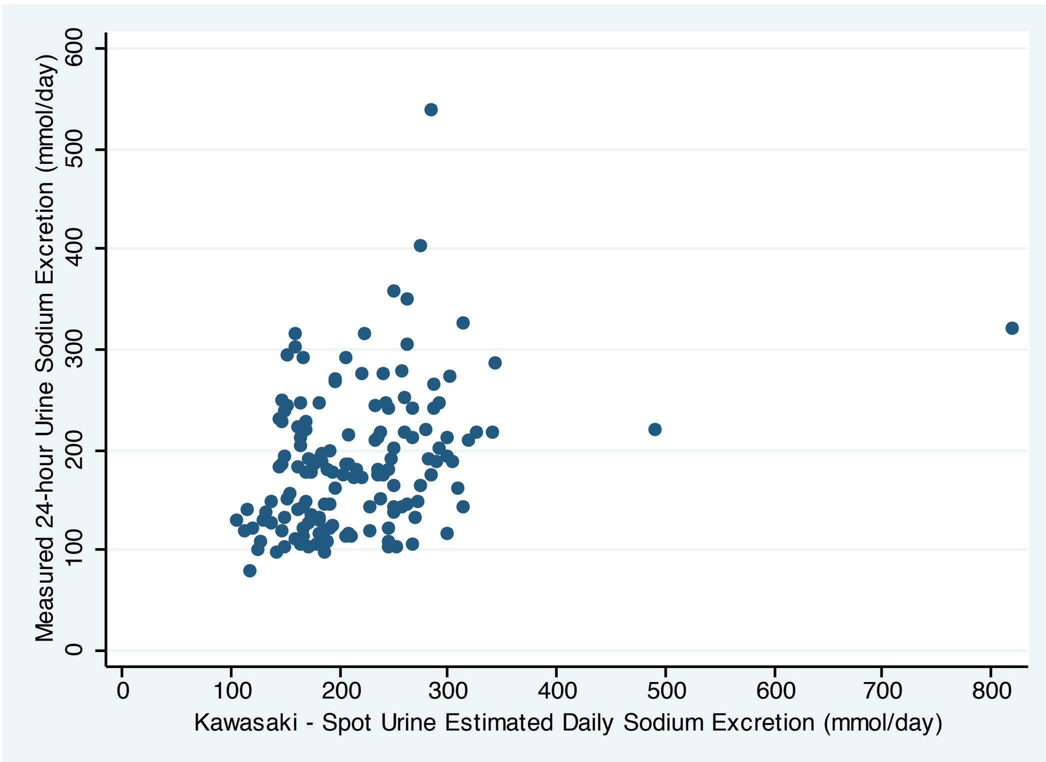
Figures

Chapter 1

Figure 1.1. Correlation Between Measured 24-hour Urinary Sodium Excretion and Spot Urine Estimated Daily Sodium Excretion (Tanaka)

Figure 1.2. Correlation Between Measured 24-hour Urinary Sodium Excretion and Spot Urine Estimated Daily Sodium Excretion (Kawasaki)



Chapter 2

Figure 2.1a. Daily Salt Intake - Men

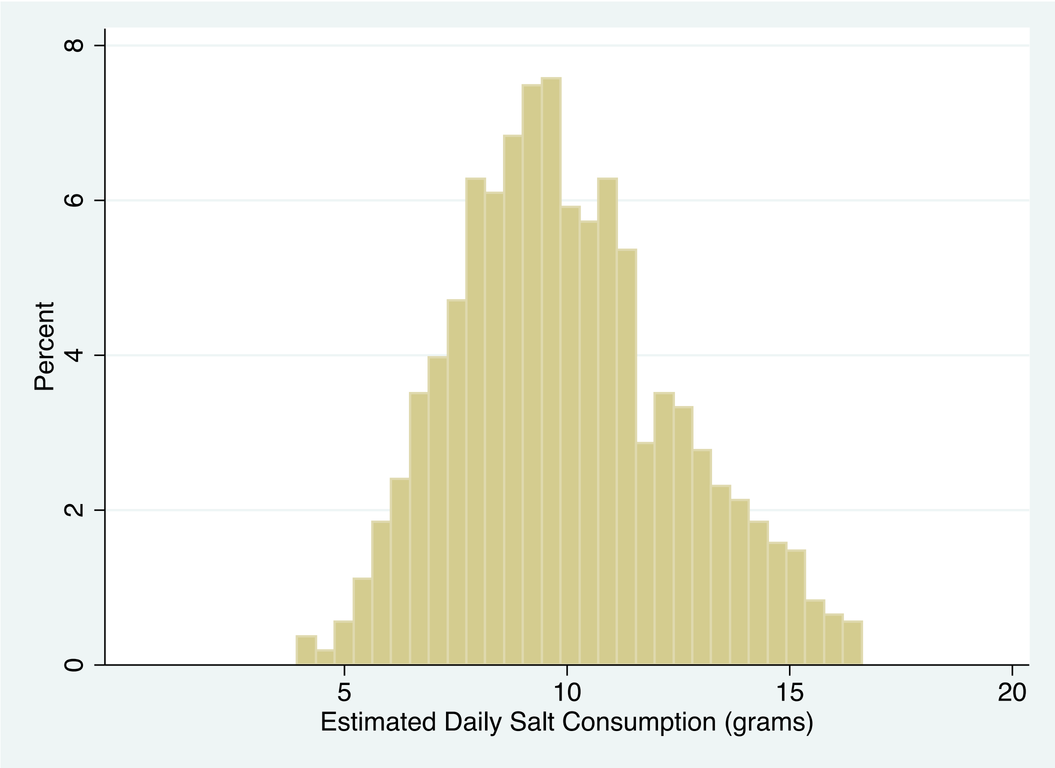
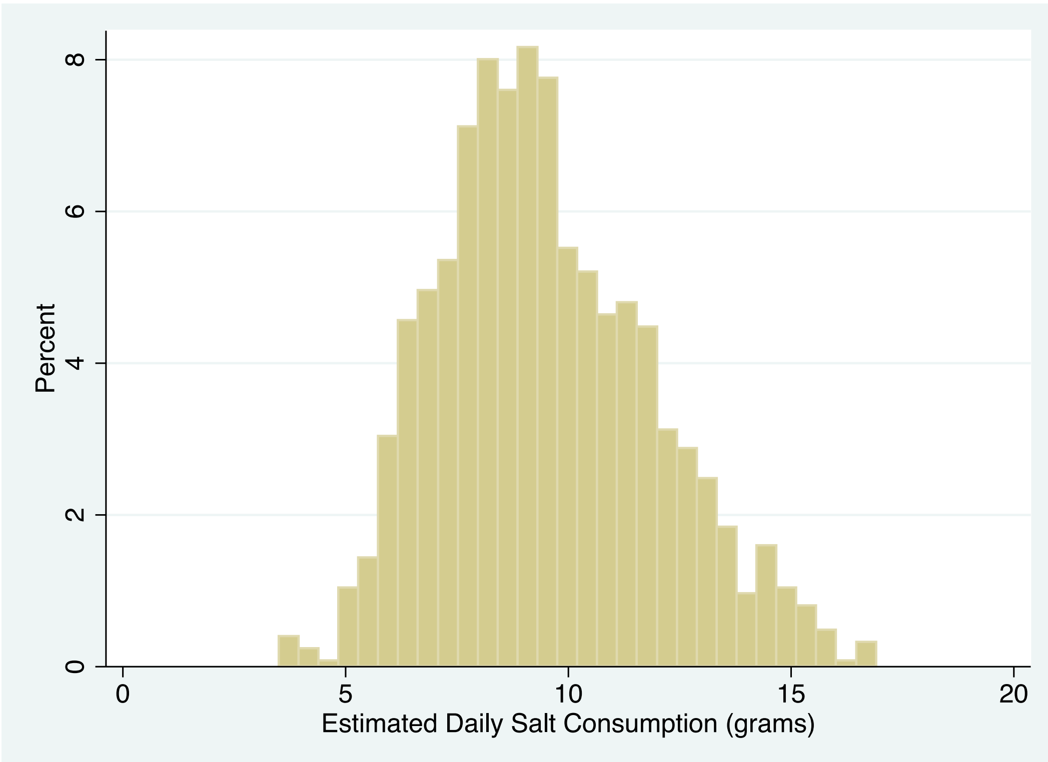
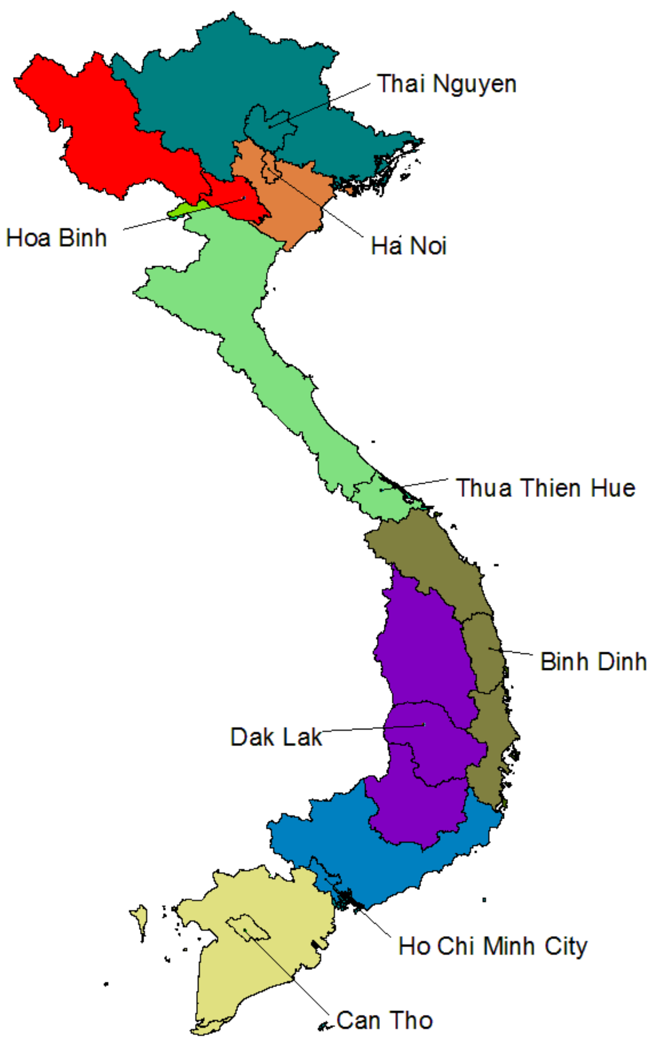


Figure 2.1b. Daily Salt Intake – Women



Chapter 3

Figure 3.1. Sampled provinces and the regions of Viet Nam they represent



Thai Nguyen represents Northeast; Hoa Binh, Northwest; Ha Noi, Red River Delta; Thua Thien Hue, North Central; Binh Dinh, South Central Coast; Dak Lak, West Highlands; Ho Chi Minh City, South East; Can Tho, Mekong Delta

Figure 3.2a. Age-specific NCD risk factor prevalence - Women

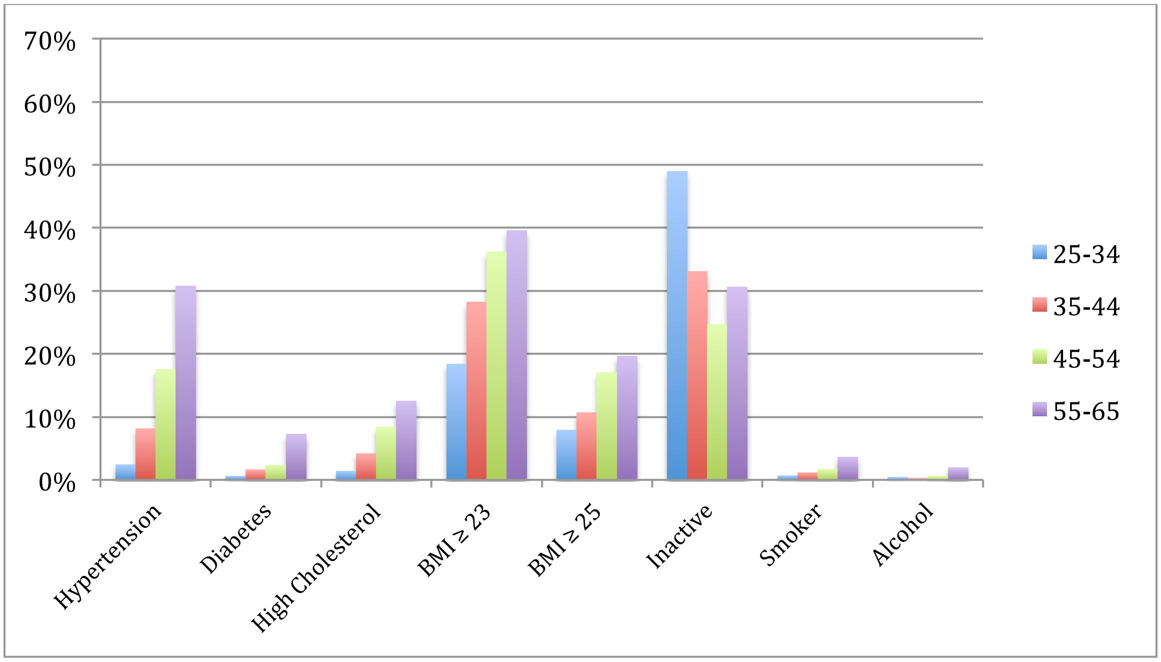


Figure 3.2b. Age-specific NCD risk factor prevalence - Men

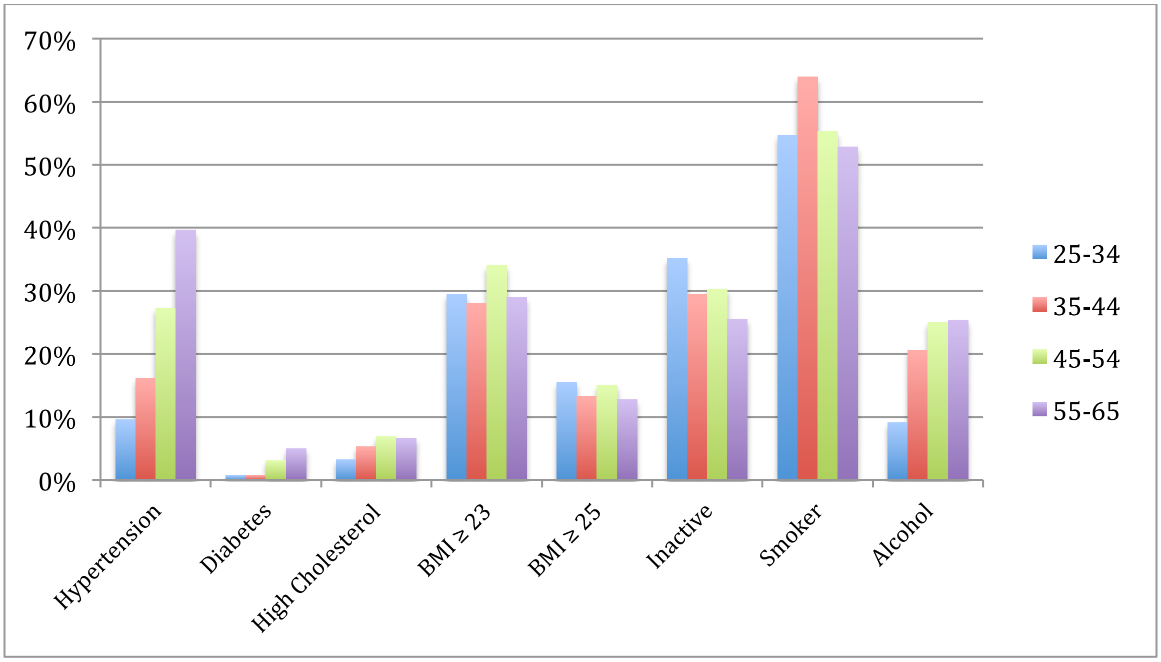


Figure 3.3a. Age-specific NCD risk factor prevalence – Rural Women

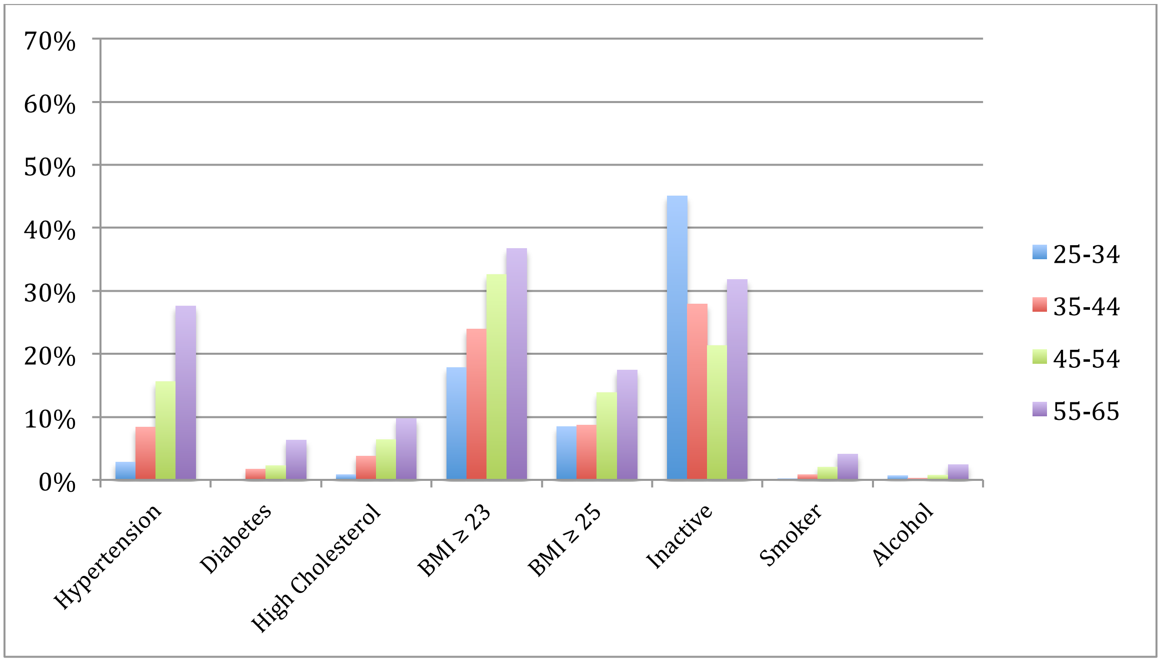


Figure 3.3b. Age-specific NCD risk factor prevalence – Urban Women

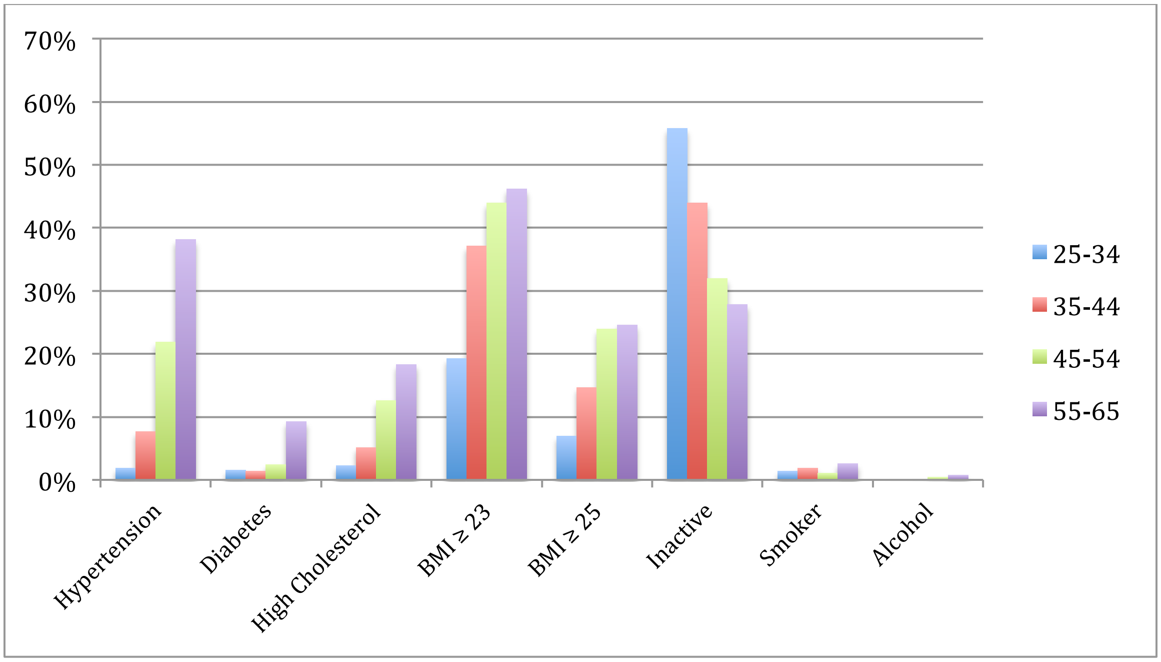


Figure 3.3c. Age-specific NCD risk factor prevalence – Rural Men

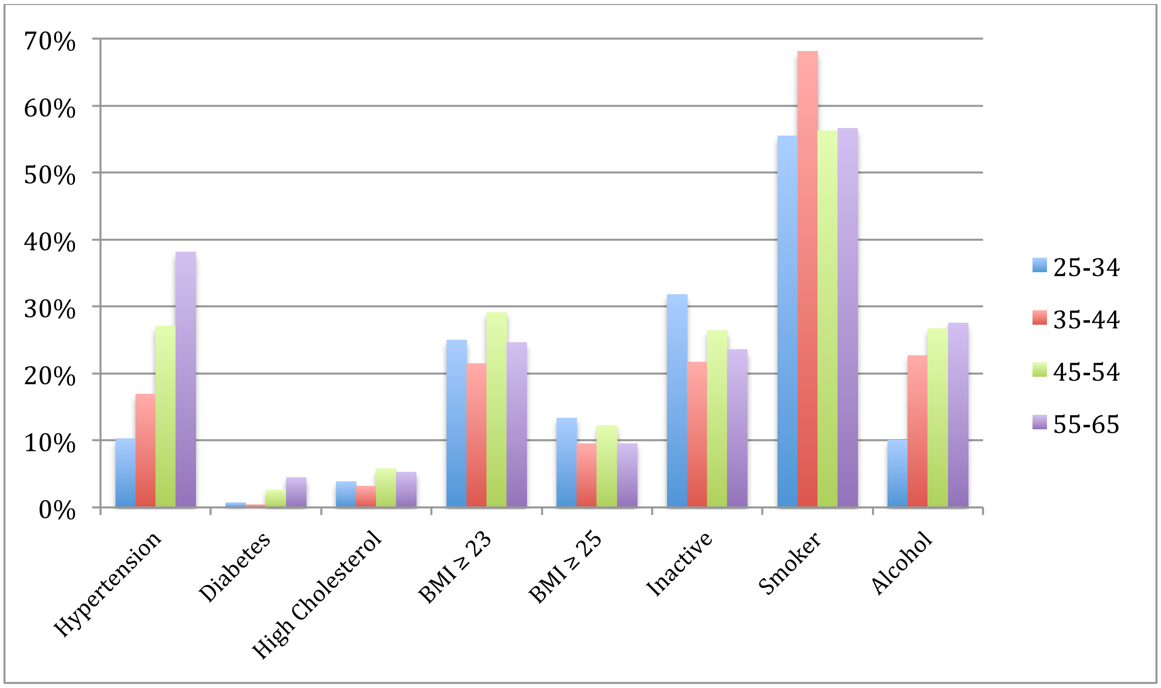
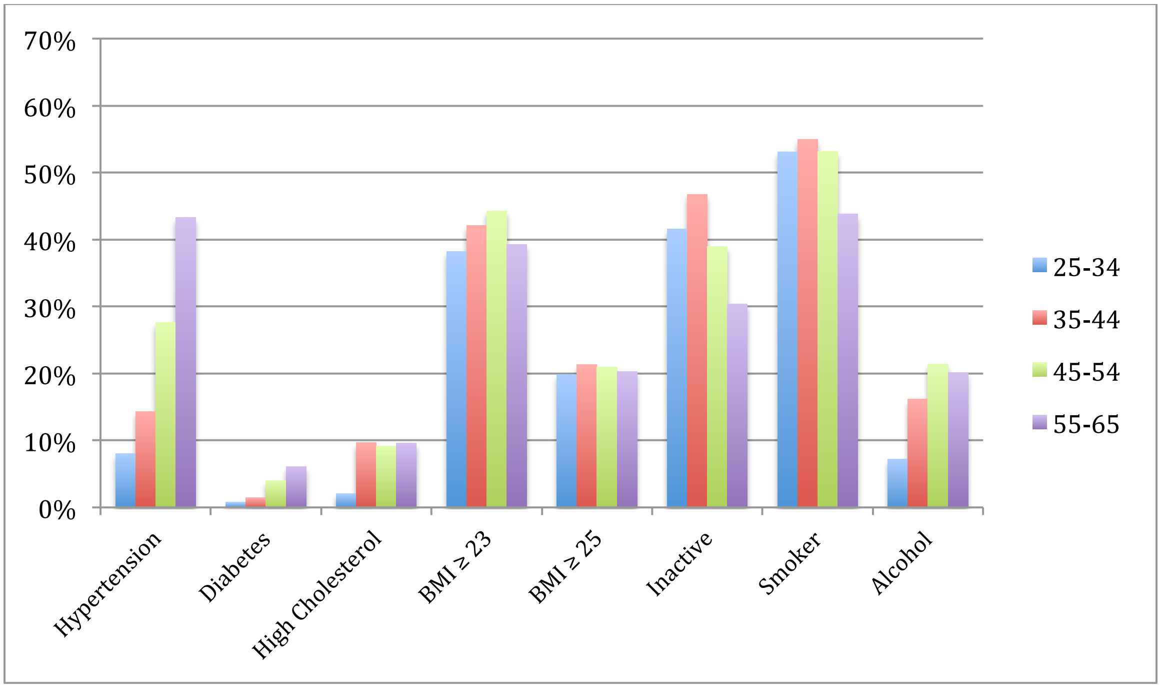


Figure 3.3d. Age-specific NCD risk factor prevalence – Urban Men



Tables

Chapter 1

Table 1.1. Participant Characteristics

	Men (N=66)		Women (N=80)	
	Mean or %	SD	Mean or %	SD
Age (years)	46	12	43	11
Height (cm)	161	7	152	5
Weight (kg)	53	7	46	7
BMI (cm/kg^2)	20	2	20	3
History of Smoking	80%		1%	
24-hour Urine Volume (ml)	1306	407	1138	357
24-hour Urine Creatinine Excretion (mg/day)	1003	377	848	224
24-hour Urine Sodium Concentration (mmol/day)	196	71	182	71
Spot Urine Creatinine Concentration (mg/dL)	1321	744	1109	544
Spot Urine Sodium Concentration (mmol/L)	193	68	195	69

Table 1.2. Daily Measured and Estimated Sodium Excretion Values (mmol/day) and Correlation Coefficients

	N	Mean	SD	Range	ρ*
Men					
24-hour urine	66	196	71	97 - 404	
Spot Urine (Tanaka)		170	52	94 - 474	0.31
Spot Urine (Kawasaki)		225	94	104 - 819	0.30
Women					
24-hour urine	80	182	71	80 - 541	
Spot Urine (Tanaka)		161	38	102 - 317	0.40
Spot Urine (Kawasaki)		209	63	115 - 490	0.39
Total					
24-hour urine	146	188	71	80 - 541	
Spot Urine (Tanaka)		165	45	94 - 474	0.35
Spot Urine (Kawasaki)		216	79	104 - 819	0.34

*Pearson correlation coefficient: relative to 24-hour urine measurement

Table 1.3. Agreement Between 24-hour Urine Measured Sodium And Spot Urine Estimated Sodium (Tanaka)

		24-hour urine collection				
		<135mmol/day	135-179mmol/day	180-225mmol/day	>225mmol/day	Total
Spot urine estimated (Tanaka)	<135mmol/day	**14**	7	7	9	37
	135-179mmol/day	16	**18**	14	9	57
	180-225mmol/day	7	11	**12**	16	46
	>225mmol/day	0	0	4	**2**	6
	Total	37	36	37	36	146

Table 1.4. Agreement Between 24-hour Urine Measured Sodium And Spot Urine Estimated Sodium (Kawasaki)

		24-hour urine collection				
		<135mmol/day	135-179mmol/day	180-224mmol/day	>=225mmol/day	Total
Spot urine estimated (Kawasaki)	<135mmol/day	**7**	2	0	0	9
	135-179mmol/day	12	**11**	10	11	44
	180-224mmol/day	10	8	**8**	6	32
	>=225mmol/day	8	15	19	**19**	61
	Total	37	36	37	36	146

Chapter 2

Table 2.1. Participant Characteristics*

	Men		Women	
	Mean or %	SE	Mean or %	SE
Age (years)	37	0.34	37	0.45
Height (cm)	163	0.38	153	0.31
Weight (kg)	59	1.06	50	0.46
BMI (kg/m^2)	22	0.36	21	0.15
Current smoker	59%	0.04	2%	0.01
≥ 5 Alcoholic drinks/week	15%	0.02	0%	0.00
Physically inactive	32%	0.03	39%	0.04
Urban residence	31%	0.02	34%	0.02
Kinh ethnicity	97%	0.01	98%	0.00
Systolic BP (mmHg)	123	0.95	113	0.88
Diastolic BP (mmHg)	75	0.80	70	0.67
Hypertension	15%	0.02	5%	0.01
Fasting Glucose (mmol/L)	4.2	0.11	3.9	0.05
Diabetes	12%	0.03	9%	0.02
Total Cholesterol (mmol/L)	4.7	0.05	4.7	0.05
Estimated salt intake* (g/day)	10.2	0.19	9.5	0.15

*Weighted with sampling weights

**Estimated using the Tanaka formula[7]

Table 2.2. Sex-stratified regression models of salt intake (g/day) with untreated systolic blood pressure and prevalent hypertension

	Minimally Adjusted Model*		Primary Model**	
		95% CI		95% CI
Systolic Blood Pressure (mmHg)				
Men	β = -0.20	-1.03, 0.63	β = -0.20	-1.03, 0.63
Women	β = 0.29	-0.26, 0.84	β = 0.29	-0.26, 0.84
Hypertension**				
Men	RR = 0.94	0.79, 1.12	RR = 0.94	0.79, 1.12
Women	RR = 0.98	0.88, 1.09	RR = 0.98	0.88, 1.09

*Includes age and body mass index as adjustment covariates

**Includes age, height, weight, smoking, total cholesterol, diabetes, and physical inactivity as adjustment covariates

***Systolic blood pressure ≥ 140mmHg or diastolic blood pressure ≥ 90mmHg

Table 2.3. Age-, Smoking-, Alcohol-, and Rural/Urban-stratified adjusted* regression models of salt intake (g/day) with untreated systolic blood pressure and prevalent hypertension

		Systolic Blood Pressure				Hypertension			
	Mean Salt Intake (g/day)	Mean (mmHg)	β	95% CI	*p***	Prevalence	RR	95% CI	*p***
Age***									
<45 years	10.0	117	-0.08	-0.67, 0.50		9%	0.96	0.85, 1.10	
≥45 years	9.6	124	0.15	-0.52, 0.81	0.58	18%	0.97	0.89, 1.06	0.94
Current smoker****									
No	10.3	124	-0.04	-0.85, 0.77		15%	0.99	0.82, 1.20	
Yes	10.2	123	-0.30	-1.26, 0.66	0.76	16%	0.97	0.85, 1.11	0.95
Alcohol consumption****									
<5 drinks/week	10.3	122	0.18	-0.56, 0.93		14%	1.00	0.88, 1.14	
≥5 drinks/week	9.7	129	-0.49	-1.46, 0.48	0.46	23%	1.07	0.92, 1.24	0.71
Place of residence									
Rural	10.1	118	-0.41	-0.99, 0.17		10%	0.92	0.82, 1.02	
Urban	9.5	119	0.59	-0.29, 1.46	0.02	12%	1.01	0.86, 1.18	0.29

*Includes adjustment terms for age, sex, height, weight, smoking, total cholesterol, diabetes, and physical inactivity

**p-value for interaction

***Continuous age not included as an adjustment term

****Analyses restricted to men-only

Chapter 3

Table 3.1. Population Characteristics

	Women		Men	
Variable	Mean or %	SE	Mean or %	SE
Age (years)	38	0.07	37	0.09
Height (cm)	153	0.14	163	0.16
Weight (kg)	50	0.17	58	0.32
Waist Circumference (cm)	72	0.18	75	0.30
BMI (kg/m^2)	21	0.07	22	0.10
BMI Category				
<18.5	14%	0.01	15%	0.01
18.5-22.9	61%	0.01	56%	0.01
23-24.9	15%	0.01	15%	0.01
25-27.4	7%	0.01	10%	0.01
27.5-29.9	3%	0.01	3%	< 0.01
≥30	1%	< 0.01	2%	< 0.01
Systolic Blood Pressure (mmHg)	113	0.35	122	0.47
Diastolic Blood Pressure (mmHg)	69	0.29	74	0.38
Glucose (mmol/L)	3.93	0.03	4.10	0.04
Total Cholesterol (mmol/L)	4.73	0.03	4.70	0.03
Smoking Status				

Never	98%	< 0.01	27%	0.01
Former	1%	< 0.01	15%	0.01
Current	1%	< 0.01	57%	0.01
Alcohol Consumption (days per week)				
< 1	98%	< 0.01	62%	0.01
1 - 4	1%	< 0.01	23%	0.01
≥ 5	< 1%	< 0.01	16%	0.01
Salt Consumption (g/day)	9.6	0.13	10.3	0.18
Highest Attained Education				
Primary School or less	46%	0.01	41%	0.02
Secondary or High School	40%	0.01	42%	0.01
College or greater	14%	0.01	17%	0.01
Kinh Ethnicity	97%	< 0.01	97%	< 0.01
Urban Residence	35%	< 0.01	33%	< 0.01

Table 3.2. Hypertension and Diabetes Awareness and Treatment

	Rural		Urban		Total	
	%	95% CI	%	95% CI	%	95% CI
Hypertension						
Prevalence	12%	11 – 14%	11%	1 – 13%	12%	11 – 13%
Awareness*	32%	27 – 36%	43%	37 – 49%	35%	31 – 39%
Treatment*	18%	14 – 22%	28%	23 – 33%	21%	18 – 24%
Control*	5%	2 – 8%	7%	4 – 11%	6%	4 – 8%
Diabetes						
Prevalence	1.1%	0.7 – 1.7%	1.8%	1.2 – 2.5%	1.2%	1.0 – 2.1%
Awareness*	41%	21 – 61%	42%	26 – 57%	41%	28 – 54%
Treatment*	38%	19 – 58%	34%	20 – 48%	36%	24 – 49%
Control*	26%	10 – 42%	23%	13 – 33%	25%	15 – 35%

* Among those with prevalent disease

Table 3.3. Population Characteristics Before and After Post-Stratification

	Women			Men		
	No PS	PS	% Δ*	No PS	PS	% Δ*
Age	41	38	9	41	37	9
Height (cm)	152	153	0	162	163	0
Weight (kg)	50	50	-1	57	58	-1
Waist Circumference (cm)	72	72	0	75	75	-1
BMI (kg/m^2)	21	21	0	21	22	-1
<18.5	15%	14%	6	15%	15%	2
18.5-22.9	59%	61%	-3	58%	56%	4
23-24.9	15%	15%	4	15%	15%	-3
25-27.4	7%	7%	11	9%	10%	-18
27.5-29.9	3%	3%	-7	3%	3%	-11
≥30	1%	1%	-21	1%	2%	-33
Hypertension	12%	8%	30	19%	15%	20
Systolic Blood Pressure (mmHg)	115	113	2	124	122	2
Diastolic Blood Pressure (mmHg)	70	69	2	75	74	2
Diabetes	2%	2%	21	2%	1%	19
Glucose (mmol/L)	4.04	3.93	3	4.18	4.10	2
Cholesterol >240 (mg/dL)	5%	4%	20	5%	5%	0
Total Cholesterol (mg/dL)	185	183	1	181	182	0
Smoking Status						
Never	97%	98%	-1	25%	27%	-10

Former	1%	1%	5	17%	15%	13
Current	2%	1%	34	58%	57%	0
Alcohol Consumption (days per week)						
< 1	98%	98%	0	59%	62%	-5
1 - 4	1%	1%	4	23%	23%	2
≥ 5	1%	< 1%	19	18%	16%	14
Salt Intake (g/day)	9.6	9.6	0	10.2	10.3	-1
Physically Inactive	31%	39%	-26	27%	32%	-19
Highest attained education						
Primary School or less	50%	46%	8	42%	41%	3
Secondary or High School	38%	40%	-5	43%	42%	3
College or greater	11%	14%	-21	15%	17%	-17
Kinh Ethnicity	95%	97%	-3	94%	97%	-3
Urban Residence	31%	35%	-13	30%	33%	-10

*Percent difference between non-post-stratified and post-stratified results