Original Article

Daily salt intake estimated by overnight urine collections indicates a high cardiovascular disease risk in Thailand

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This cross-sectional study (February 2012 to March 2013) was conducted to estimate daily salt intake and basic characteristics among 793 community-dwelling participants at high risk of cardiovascular disease (Framingham risk score >15%), who had visited diabetes or hypertension clinics at health centres in the Muang district, Chiang Rai, Thailand. We performed descriptive analysis of baseline data and used an automated analyser to estimate the average of 24-hour salt intake estimated from 3 days overnight urine collection. Participants were divided into two groups based on median estimated daily salt intake. Mean age and proportion of males were 65.2 years and 37.6% in the higher salt intake group (≥10.0 g/day, n=362), and 67.5 years and 42.7% in the lower salt intake group (<10.0 g/day, n=431), respectively (p=0.01, p<0.01). The higher salt intake group comprised more patients with a family history of hypertension, antihypertensive drug use, less ideal body mass index (18.5-24.9), higher exercise frequency (≥2 times weekly) and lower awareness of high salt intake. Among higher salt intake participants, those with lower awareness of high salt intake were younger and more often had a family history of hypertension, relative to those with more awareness. Our data indicated that families often share lifestyles involving high salt intake, and discrepancies between actual salt intake and awareness of high salt intake may represent a need for salt reduction intervention aiming at family level. Awareness of actual salt intake should be improved for each family.

Key Words: awareness, hypertension, behaviours salt intake, family environment, Chiang Rai

INTRODUCTION

Hypertension is one of major causes of cardiovascular events, both in developed and developing countries. In 2008, the overall prevalence of raised blood pressure in adults aged ≥25 years was around 40% worldwide.[1] However, because of population growth and ageing, the number of people with uncontrolled hypertension increased from 600 million in 1980 to nearly 1 billion in 2008.[1] In addition, 1.65 million deaths from cardiovascular causes that occurred in 2010 were attributed to sodium consumption above a reference level of 2.0 g per day.[2] Findings from the International Cooperative Study on Salt, Other Factors, and Blood Pressure (INTERSALT) and the International Study on Macronutrients and Blood Pressure (INTREMAP) studies indicated a positive association between salt intake and blood pressure in multi-ethnic populations, emphasizing the importance of salt reduction for better management of blood pressure.[3-4]

With regard to lifestyle modification including that of salt intake, several intervention trials to promote salt intake reduction have shown that a low sodium diet has the potential to reduce blood pressure.[5-6] Several educational tools as well as a salt intake measurement device that estimates 24-hour urinary sodium extractions have been introduced.[7] However, global sodium intake remains above the levels recommended by the World Health Organization (WHO), and Southeast Asia, which houses Thailand, has one of the highest sodium intake levels

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relative to other regions.[8-9] In this context, we conducted a trial in the Muang district of Chiang Rai, the northernmost province of Thailand,[10] to examine an intensive health education intervention that used visualization tools to help individuals increase their awareness of their daily salt intake. The analysis utilized baseline data for the trial, and we aimed to estimate daily salt intake and basic characteristics of participants with high salt intake among those with a high cardiovascular disease (CVD) risk in northern Thailand.

SUBJECTS AND PARTICIPANTS

Study design

This study was part of a cluster randomized trial (CRT) to examine intensive health education interventions that use visualization tools to make individuals aware of their daily salt intake, conducted from February 2013 to March 2013. Details of the study have been published previously.[10] The present study analyzed baseline data.

Participants

We screened lists of patients who had visited diabetes or hypertension clinics at eight health centres in the Muang district of Thailand and registered those who met the following eligibility criteria: (1) diabetic and hypertensive patients with high CVD risk according to the Framingham general CVD risk score (>15%) and (2) patients who were willing to participate in the study. Patients fulfilling the following criteria were excluded: (1) pregnant or trying to become pregnant, (2) younger than 35 years of age, (3) diagnosed with type I diabetes, (4) undergoing long-term steroid therapy (more than two weeks), (5) undergoing long-term non-steroidal anti-inflammatory drug (NSAID) therapy (i.e., every day for at least one year), (6) cancer, (7) known secondary hypertension such as primary aldosteronism, Cushing's syndrome or pheochromocytoma, (8) severe chronic pulmonary diseases requiring home oxygen therapy, (9) chronic renal disease (creatinine ≥2.0 mg/dL), (10) congestive heart failure and (11) a known previous diagnosis of CVD.

Variables

We interviewed patients to collect data on their basic characteristics including age, sex, medical history (hypertension, dyslipidemia, diabetes mellitus, cardiovascular disease, cerebrovascular disease, and kidney disease), and family medical history (hypertension, diabetes mellitus, cardiovascular disease and cerebrovascular disease). We also inquired about lifestyle characteristics listed in Breslow's seven health practices and defined as components of a healthy lifestyle, as follows: alcohol consumption (<3 days/week), smoking behaviour (non-current smoker), exercise frequency (≥2 times/week), body mass index (BMI; 18.5-24.9), sleep hours (6-9), breakfast consumption habits (every morning), and snacking between meals (no).[11-12]

As for awareness of salt intake issues, we asked participants "Do you know that you are at risk for CVD?", "Do you know that CVD is very dangerous?", "Do you think you eat salty food?", and "Do you make efforts to reduce your salt intake?". Participants were asked to answer these questions on a scale from 1 to 5 (Definitely=1, Not at all=5).

Body height and weight were measured with patients in a standing position. BMI was calculated based on body weight (kg) divided by height squared (m^2). Both systolic blood pressure (SBP) and diastolic blood pressure (DBP) were obtained on the upper arm using a validated oscillometric OMRON HEM-907IT device (Omron Healthcare Co., Ltd., Kyoto, Japan) after the participant had been seated for at least five minutes. The two readings were collected and the mean was presented. We also collected information for the following lipid-related items after overnight fast: total cholesterol (mmol/L; TC), high-density lipoprotein cholesterol (mmol/L; HDL-C), and triglycerides (mmol/L; TG). Low-density lipoprotein cholesterol (mmol/L; LDL-C) was estimated using the Friedwald equation ([TC] – [HDL-C] – [TG/5]).[13] Glycosylated haemoglobin A1c (National Glycohemoglobin Standard Program (NGSP) levels were determined by high-performance liquid chromatography using an automated analyzer.

A KME-03 salinity checker (Kono ME Institute, Kanagawa, Japan) was used to determine automatically the estimated daily salt intake using overnight urine.[14] Details of this method have been reported previously.[14-15] The sodium chloride concentration was adjusted by applying a correlation formula such that the concentration was between the value obtained with the ion electrode method and the value for the conductivity method (measurement of concentration by conductivity is affected by other electrolytes such as potassium). Overnight urine volume was measured using a resistance sensor, while the overnight urinary sodium chloride concentration was measured by a conductivity sensor; these values were then integrated. The monitoring device estimates automatically 24-hour salt excretion from overnight urine samples by using the following formula: Y (g/day) = 1.95X (g) + 4.5, where Y is the estimated 24-hour urinary salt excretion and X is the sodium content of the overnight urine sample.[14] We asked participants to store overnight urine accurately. And then, these participants brought over-night collected urine to health centre and staff members measured the estimated 24-hour urinary salt excretion. The same procedure was repeated for three successive days. We calculated an average of the measurements of three successive days and defined as "estimated daily salt intake".

Statistical analysis

Results are presented as mean ± standard deviation (SD) for continuous variables or prevalence (%) for categorical variables. We used the two-sided student's t-test for continuous variables and the chi-square test or Fisher's exact test for comparisons between two groups. All significance tests were two-sided, and *p*-values less than 0.05 were considered statistically significant. All data were analyzed using SPSS version 22 (IBM SPSS Inc., Chicago, USA).

The Ethics Committee of Juntendo University approved the research protocol (No. 2011036), and the research protocol was registered in the International Standard Randomized Controlled Trial Number Register (ISRCTN39416277). We obtained informed consent from all participants.

Table 1. Basic characteristics at baseline (n=793)

	Mean (SD) or n (%)
Age (years)	66.5 (8.9)
Sex (men)	412 (51.8)
Anthropometric measurements	
Height (cm)	155 (7.8)
Weight (kg)	59.1 (9.1)
Body mass index	24.6 (3.8)
Atherosclerotic complications	
Cardiovascular disease	11 (1.4)
Cerebrovascular disease	15 (1.9)
Kidney disease	6 (0.8)
Family histories	
Cardiovascular disease	29 (3.6)
Cerebrovascular disease	19 (2.4)
Hypertension	248 (31.2)
Diabetes mellitus	171 (21.5)
Hypertension-related factors	
Systolic blood pressure (mmHg)	149 (19.5)
Diastolic blood pressure (mmHg)	75.0 (11.7)
Antihypertensive drug use (yes)	687 (86.4)
Lipid-related items	
Total cholesterol (mmol/L)	4.95 (0.96)
High-density lipoprotein cholesterol (mmol/L)	1.10 (0.28)
Low-density lipoprotein cholesterol (mmol/L)	3.07 (0.83)
Triglycerides (mmol/L)	2.07 (1.33)
Antidyslipidemic drug use (yes)	224 (28.2)
Diabetes-related items	
Haemoglobin A1c (%)	6.2 (1.2)
Antidiabetic drug use (yes)	335 (42.1)
Healthy lifestyle characteristics	
Alcohol consumption (≤3 days/week)	762 (95.8)
Smoking behavior (non-current smoker)	722 (90.8)
Exercise frequency (≥2 times per week)	196 (24.7)
Body mass index (18.5-24.9)	381 (49.1)
Sleep duration (6-9 hours)	531 (66.8)
Breakfast consumption (every morning)	762 (95.8)
Snack between meals (no)	416 (52.3)
Total number of healthy lifestyle items	
Participants with 6 or 7 total number of healthy lifestyle items	179 (23.1)
Estimated daily salt intake (g/day)	9.9 (2.3)
Volume of overnight urine (mL)	548 (208)
Awareness of salt intake issues (yes)	
Awareness of CVD risk factors	290 (36.6)
Awareness of serious nature of CVD	556 (70.1)
Awareness of high salt intake	639 (80.6)
Motivation to reduce salt intake	488 (61.5)

RESULTS

At baseline, 793 participants were registered in the study (Table 1). Mean age was 66.5 (SD 8.9) years and the proportion of males was 51.8%. Mean BMI was 24.6 (3.8). Prevalence with cardiovascular and cerebrovascular disease was 1.4% and 1.9%, respectively. As for family histories, hypertension was the most frequent (31.2%), followed by diabetes mellitus (21.5%). Mean SBP and DBP were 149 (19.5) and 75.0 (11.7) mmHg, respectively. As for lifestyle-related medications, 86.4% received antihypertensive drugs, 28.2% received antidyslipidemic drugs, and 42.1% received antidiabetic drugs. Proportion of participants with a healthy lifestyle (total of six or seven for the number of healthy lifestyle items) was 23.1%. Mean of estimated daily salt intake was 9.9 (2.3) g/day.

Awareness of the serious nature of CVD and high salt intake was 70.1% and 80.6%, respectively, whereas that of CVD risk factors was 36.6%.

Specific characteristics related to estimated salt intake are shown in Table 2 by mean salt intake. Those in the higher salt intake group (≥10.0 g/day) were likely to be younger, with more females. In addition, the higher salt intake group comprised more patients with a family history of hypertension, antihypertensive drug use and exercise frequency ≥2 times weekly. In contrast, the higher salt intake group had a lower ideal BMI (18.5-24.9) and lower awareness of high salt intake compared to the lower salt intake group.

Those in the higher salt intake group with lower awareness of their high salt intake were younger, more often had a family history of hypertension, and were less aware of CVD risk factors, relative to those with more awareness of their high salt intake (Table 3).

DISCUSSION

Descriptive analysis of baseline data showed characteristics associated with higher salt intake, which included high levels of hypertensive medication, family history of hypertension, and low awareness of high salt intake. Mean estimated daily salt intake of all participants was 9.9 g/day, which was higher than the recommended salt intake (5 g/day).[8] In fact, mean salt intake is estimated more than 11.7 g/day in many Asian countries, and salt intake reduction remains a public health challenge in this particular region.[15-16] Higher salt intake group were younger, less ideal BMI (18.5-24.9) and higher exercise frequency compared to lower salt intake group, because they might have higher energy requirements and tended to be more physically active and therefore eat more. Among those in the higher salt intake group, those with low awareness of high salt intake were likely to have a family history of hypertension. We are only aware of a few studies which examined salt intake and analysed characteristics among higher salt intake individuals in rural communities in Thailand. We found that the higher salt intake group had lower awareness of higher salt intake compared to the lower salt intake group. There are several possible explanations.[17-18] One is a sensory habituation to salt.[17] In a matched case-control study conducted in Nigeria among 175 diabetic subjects, the taste threshold for sodium chloride recognition showed a significant association with mean arterial pressure after adjustment for confounding factors.[18] A Japanese cross-sectional study reported that taste preference of miso soup was significantly associated with both 24-hour urinary extraction and daily sodium intake.[19] Sensory habituation to higher salt intake might be resulting in increased liking for high sodium concentrations in food.[20] As a food environment became saltier, habituation to higher salt intake may have occurred. Thus, decreased linking to high sodium concentrations in food may contribute to reduced salt consumption.

On a related note, knowledge and behaviours surrounding salt consumption are important issues. A cross-sectional survey conducted in Korea among 189 adult participants reported that salt usage behaviour assessed by a questionnaire was significantly correlated to 24-hour

Table 2. Specific characteristics related to estimated salt intake

	Mean (SD) or n (%) Estimated salt intake (g/day)		p-value†
	<10.0 (n=431)	≥10.0 (n=362)	
Age (years)	67.5 (9.0)	65.2 (8.6)	0.01
Sex (men)	184 (42.7)	136 (37.6)	<0.01
Anthropometric measurements			
Height (cm)	154 (7.6)	157 (7.7)	<0.01
Weight (kg)	56.8 (10.5)	61.8 (11.6)	<0.01
Body mass index	24.1 (3.6)	25.1 (3.9)	0.18
Atherosclerotic complications			
Cardiovascular disease	5 (1.2)	6 (1.7)	0.56
Cerebrovascular disease	8 (1.9)	7 (1.9)	0.55
Kidney disease	3 (0.7)	3 (0.8)	0.83
Family histories			
Cardiovascular disease	14 (3.2)	15 (4.1)	0.50
Cerebrovascular disease	8 (1.9)	11 (3)	0.28
Hypertension	128 (29.8)	120 (33.1)	0.03
Diabetes mellitus	91 (21.1)	79 (21.8)	0.81
Hypertension-related factors			
Systolic blood pressure (mmHg)	149 (19.8)	150 (19.1)	0.44
Diastolic blood pressure (mmHg)	74.0 (11.6)	76.2 (11.7)	0.66
Antihypertensive drug use (yes)	363 (84.2)	323 (89.2)	0.04
Lipid-related items			
Total cholesterol (mmol/L)	4.96 (0.93)	4.94 (0.99)	0.37
High-density lipoprotein cholesterol (mmol/L)	1.09 (0.25)	1.10 (0.31)	0.07
Low-density lipoprotein cholesterol (mmol/L)	3.13 (0.79)	3.00 (0.88)	0.36
Triglycerides (mmol/L)	1.95 (1.28)	2.21 (1.38)	0.21
Antidyslipidemic drug use (yes)	129 (30.0)	93 (25.7)	0.65
Diabetes-related items			
Haemoglobin A1c (%)	6.2 (1.3)	6.1 (1.2)	0.87
Antidiabetic drug use (yes)	187 (43.4)	146 (40.3)	0.39
Healthy lifestyle characteristics			
Alcohol consumption (≤3 days/week)	417 (96.8)	343 (94.8)	0.16
Smoking behavior (non-current smoker)	394 (91.4)	327 (90.3)	0.60
Exercise frequency (≥2 times per week)	92 (21.3)	104 (28.7)	0.02
Body mass index (18.5-24.9)	223 (53.2)	157 (44.2)	0.01
Sleep duration (6-9 hours)	296 (68.7)	233 (64.4)	0.20
Breakfast consumption (every morning)	412 (95.6)	348 (96.1)	0.70
Snack between meals (no)	227 (52.7)	188 (51.9)	0.84
Total number of healthy lifestyle items			
Participants with 6 or 7 total number of healthy lifestyle items	100 (23.9)	79 (22.3)	0.60
Estimated daily salt intake (g/day)	8.3 (1.2)	11.9 (1.6)	<0.01
Volume of overnight urine (mL)	492 (185)	614 (214)	<0.01
Awareness of salt intake issues (yes)			
Awareness of CVD risk factors	149 (34.6)	141 (39.0)	0.20
Awareness of serious nature of CVD	305 (70.8)	251 (69.3)	0.66
Awareness of high salt intake	367 (85.2)	272 (75.1)	<0.01
Motivation to reduce salt intake	258 (59.9)	230 (63.5)	0.29

†p value was estimated by the two-sided student's t-test for continuous variables and the chi-square test or Fisher's exact test for categorical variables to compare two groups.

urinary sodium extraction.[21] An Australian study of 1,084 participants aged ≥14 years indicated that 67% knew that salt was bad for health, whereas only 14% knew the recommended maximum daily salt intake.[22] Therefore, effective interventions to improve awareness, knowledge, and behaviour are required. In fact, an intervention study conducted in Australia among 49 healthy adults revealed that 24-hour urinary sodium extraction was significantly reduced after eight weeks of dietary education. However, the study indicated that barriers to salt reduction were limited food variety and choice, difficulty when eating out, and increased time associated with identifying foods.[23]

Our results showed that, among those in the higher salt intake group, those with low awareness of high salt intake were more likely to have a family history of hypertension. With regard to family history, family genetics and environment may also be associated. The Victorian Family Heart Study reported that sharing the same genetics and many family environmental factors determined variation in both SBP and DBP.[24] Dietary habits are especially likely to be shared within the same family. A cross-sectional study reported that children's salt intake may be accurately assessed by the mother's salt intake behaviour rather than children's own salty taste performance, suggesting the importance of the mother's role in salt restriction education for children.[25] Thus, intervention programs targeting families may be necessary for sufficient salt intake reduction.

This study has several limitations, including selection

Table 3. Specific characteristics related to awareness of high salt intake among participants with higher salt intake (≥10.0 g/day)

	Mean (SD) or n (%)		p-value†
	Awareness of high salt intake		
	No (n=90)	Yes (n=272)	
Age (years)	63.0 (8.4)	65.9 (8.6)	<0.01
Sex (men)	62 (68.9)	164 (60.3)	0.14
Anthropometric measurements			
Height (cm)	158 (6.9)	156 (8.0)	0.04
Weight (kg)	63.9 (10.9)	61.0 (11.7)	0.04
Body mass index	25.5 (3.9)	25.0 (4.0)	0.37
Atherosclerotic complications			
Cardiovascular disease	3 (3.3)	3 (1.1)	0.15
Cerebrovascular disease	1 (1.1)	6 (2.2)	0.51
Kidney disease	1 (1.1)	2 (0.7)	0.73
Family histories			
Cardiovascular disease	5 (5.6)	10 (3.7)	0.44
Cerebrovascular disease	4 (4.4)	7 (2.6)	0.37
Hypertension	39 (43.3)	81 (29.8)	0.02
Diabetes mellitus	23 (25.6)	56 (20.6)	0.32
Hypertension-related factors			
Systolic blood pressure (mmHg)	149 (19.0)	150 (19.1)	0.47
Diastolic blood pressure (mmHg)	77.4 (11.2)	75.6 (11.9)	0.26
Antihypertensive drug use (yes)	82 (91.1)	241 (88.6)	0.51
Lipid-related items			
Total cholesterol (mmol/L)	4.84 (0.84)	4.98 (1.04)	0.43
High-density lipoprotein cholesterol (mmol/L)	1.16 (0.33)	1.07 (0.31)	0.13
Low-density lipoprotein cholesterol (mmol/L)	2.89 (0.83)	3.04 (0.89)	0.36
Triglycerides (mmol/L)	2.16 (1.36)	2.22 (1.40)	0.80
Antidyslipidemic drug use (yes)	25 (78.1)	68 (70.8)	0.42
Diabetes-related items			
Haemoglobin A1c (%)	6.3 (1.3)	6.1 (1.1)	0.24
Antidiabetic drug use (yes)	39 (43.3)	107 (39.3)	0.50
Healthy lifestyle characteristics			
Alcohol consumption (≤3 days/week)	84 (93.3)	259 (95.2)	0.49
Smoking behaviour (non-current smoker)	81 (90.0)	246 (90.4)	0.90
Exercise frequency (≥2 times per week)	28 (31.1)	76 (27.9)	0.57
Body mass index (18.5-24.9)	37 (42.0)	120 (44.9)	0.64
Sleep duration (6-9 hours)	64 (71.1)	169 (62.1)	0.12
Breakfast consumption (every morning)	87 (96.7)	261 (96.0)	0.76
Snack between meals (no)	49 (54.4)	139 (51.1)	0.58
Total number of healthy lifestyle items			
Participants with 6 or 7 total number of healthy lifestyle items	24 (27.3)	55 (20.6)	0.19
Estimated daily salt intake (g/day)	12.1 (1.5)	11.8 (1.7)	0.20
Volume of overnight urine (mL)	612 (206)	615 (217)	0.89
Awareness of salt intake issues (yes)			
Awareness of CVD risk factors	49 (54.4)	92 (33.8)	<0.01
Awareness of the serious nature of CVD	64 (71.1)	187 (68.8)	0.67
Motivation to reduce salt intake	62 (68.9)	168 (61.8)	0.22

†p value was estimated by the two-sided student's t-test for continuous variables and the chi-square test or Fisher's exact test for categorical variables to compare two groups.

bias. The study was conducted in the Muang district in Thailand, and participants comprised those who lived in the community. Therefore, extrapolation of our results may not be appropriate for other districts in Thailand. In addition, sample size may have been relatively small compared to other previous studies. Large-scale, multicentre studies will be needed in the future. Second, we registered only participants with higher cardiovascular risks in the present study. Third, the validity of the automated device to estimate 24-hour salt intake using overnight urine was already assessed among Japanese, but not other ethnicities. In addition, we could not collect dietary sodium in the study and consider effect of diuretics for sodium excretion in urine. In further analysis, assessing the validity is required using actual overnight sodium excretion with urine volume. Finally, we were unable to assess family-based environmental factors. Assessment which considers family environment will be necessary for salt reduction intervention programs which include family support.

In conclusion, descriptive analysis of baseline data revealed characteristics associated with higher salt intake, which included high levels of hypertensive medication, family history of hypertension, and low awareness of high salt intake. Among the high salt intake group, those with low awareness of high salt intake were more likely to have a family history of hypertension. Our data indicated that families often share lifestyles involving higher salt intake, and discrepancies between actual salt intake and awareness of high salt intake may represent a need for salt reduction. Awareness of actual salt intake should be improved for each family.

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AUTHOR DISCLOSURES
The authors have no conflicts of interest to declare.

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Original Article

Daily salt intake estimated by overnight urine collections indicates a high cardiovascular disease risk in Thailand

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隔夜尿液評估泰國高心血管疾病風險參與者每日鹽攝取量

此橫斷性研究（2012 年 2 月至 2013 年 3 月）為評估居住在社區具高心血管疾病風險（Framingham 危險分數>15%）的 793 名參與者的鹽攝取量及其基本特性，他們曾因糖尿病或是高血壓至泰國清萊府 Muang 區的健康中心就診。我們分析參與者的基本特性，並使用自動化分析儀評估所收集的三天隔夜尿液，藉此推估平均 24 小時鹽攝取量。依照估算的每日鹽攝取量中位數將參與者分成高鹽（≥10.0 g/day，n=362）及低鹽（<10.0 g/day，n=431）攝取量組，兩組對象平均年齡及男性比例分別為 65.2 歲、67.5 歲及 37.6%、42.7%（p=0.01, p<0.01）。高鹽攝取組有較多參與者有家族高血壓病史、使用抗高血壓藥、較少人介於理想身體質量指數範圍（18.5-24.9）、較高的運動頻率（每週大於等於兩次）與較低的高鹽攝取認知。在高鹽攝取組中，那些對高鹽攝取認知低者比起相對認知高者，較為年輕且有較多人有家族高血壓病史。我們的資料顯示，家庭成員經常共有涉及高鹽攝取的生活習慣。而實際鹽分攝取量與對高鹽攝取認知之間的差異可能代表需要將減鹽介入的目標放在家庭層次。每個家庭之實際鹽分攝取量的認知應該被改善。

關鍵字：認知、高血壓、鹽攝取行為、家庭環境、清萊