Understanding and Managing Cardiovascular Disease Risk Factors in Vietnam

*Integrating Clinical and Public Health Perspectives*

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“Superior doctors prevent the disease
Mediocre doctors treat the disease before it is evident
Inferior doctors treat the full blown disease”

Adapted from Huangdi Neijing, 2600 BC

To my family and my country
Prologue

My first involvement in epidemiology happened in 1994 when I received a diskette with Epi-Info from one of my old friends, who shared with me an interest in software. Acting on the advice of my older brother to apply it to my medical field, I tried to master this software, and use it to analyse data for my colleagues. I then learned more sophisticated procedures and got familiar with statistics. This experience also gave me more opportunities to work with clinical doctors and later contributed to my becoming a cardiologist. When training as a cardiology resident at the Vietnam National Heart Institute (VNHI), I joined in some surveys sponsored by World Health Organization (WHO), which were organized by Dr. Pham Thai Son, the secretary of WHO’s project at VNHI at that time (2001). Since then, we have worked together in many community projects and epidemiological surveys and intervention studies around the country. After becoming an official lecturer of Department of Cardiology of Hanoi Medical University (HMU) in 2002, I was recruited into the Health System Research Project (HSRP) at HMU and took the 3-week summer course in Umeå, June 2003. That was the first time I visited Umeå, met interesting teachers from the Division of Epidemiology and Public Health, and learned the basics in statistics, qualitative studies and public health.

Since 2001, I have been working as an intervention cardiologist at VNHI (an affiliated hospital of HMU). Returning to VNHI after nearly 18 months abroad on a fellowship in intervention cardiology (2004-2005), I focused more on the spectrum of vulnerable plaques in coronary arteries and percutaneous coronary interventions to fix these culprit lesions. These procedures always required careful consideration of the balance between latest clinical evidence and individual socioeconomic characteristics of any patients in order to achieve the best results in the short term as well as to protect them from later fatal complications. The more procedures I performed, the more I recognised the importance of preventive strategies to delay the onset of disease or to effectively control cardiovascular risk factors in order to avoid costly procedures, which can easily bankrupt any family without significantly changing mortality at advanced stages of cardiovascular disease. With this in mind, I tried to arrange time to participate in population studies at VNHI, which explored the burden of cardiovascular disease and potential solutions for the general population of Vietnam.

In 2007, I registered as a research student in Umeå University, a few months after Dr Son registered. Both of us started a new journey together in Sweden, spending 2-3 months a year studying new subjects in epidemiology and
global health. Sharing a big project of prevention and management of hypertension in Vietnam under the same group of supervisors, we explored two different but complementary directions. Dr Son focused more on hypertension itself and the specific management of hypertension, in a vertical manner. I focused more on the general interactions of cardiovascular disease risk factors, including hypertension, in a more horizontal direction. Both approaches intersected at the point of hypertension and reflected our critical thinking pathway from epidemiological vision to interventional actions in the community. Working together very closely and becoming co-authors for almost all manuscripts, we used different datasets and study designs to scrutinize our approaches, leading to independent topics and themes for discussion not only in our own thesis but also in the papers in which Dr Son or I was separately the principal author. We expect readers will appreciate the divergence and the complementarity of our works, which should be considered as twinned visions and actions.

This thesis partially reflects the maturation in my perception from a purely clinical point-of-view to the comprehensive panorama of health science. Often lonely, being far away from my beloved, keeping away from my favourite challenging procedures in catheterization laboratory, being stuck sometimes in analysing data or writing manuscripts... if I say I am still very happy and never regret anything, I would be untruthful. However, being involved in community projects, contributing to social works, seeing the benefits and happiness people received from our completed actions, I feel fortunate to be on this right track. In addition to the inspiration from sharing and collaboration, I have gained a lot of invaluable experience and knowledge in methodology, anthropology and also philosophy. “Happiness is a journey, not a destination”. This thesis is a temporary stopover for me during my endless scientific journey to refine myself and bring benefits to other people.
Abstract

**Background:** Vietnam, like other low-income countries, is facing an epidemic burden of cardiovascular disease risk factors (CVDRFs). The magnitude and directions of CVDRF progression are matters of uncertainty.

**Objectives:** To describe the epidemiological progression of CVDRFs and the preventive effects of community lifestyle interventions, with reference to the differences in progression of CVDRF patterns between men and women.

**Methods:** The study was conducted during 2001-2009 in nationally representative samples and in a local setting of rural areas of Ba-Vi district, Ha-Tay province. Both epidemiological and interventional approaches were applied: (i) a population-based cross-sectional survey of 2,130 people aged ≥25 years in Thai-Binh and Hanoi; (ii) an individual participant-level meta analysis of 23,563 people aged 24-74 years from multiple similar surveys in 9 provinces around Vietnam; (iii) a 17-month cohort study of 497 patients in a hypertension management programme; (iv) a quasi-experimental trial on community lifestyle promotion integrated with a hypertension management programme, evaluated by surveys of 4,645 people in both intervention and reference communes before and after a 3-year intervention.

**Main findings:** (i) in the general adult population ≥25 years, CVDRFs were common, often clustered within individuals, and increased with age; (ii) the Vietnamese population is facing a growing epidemic of CVDRFs, which are generally not well managed; (iii) it is possible to launch a community intervention in low-resource settings within the scope of a commune-based patient-targeted programme on hypertension management; (iv) community health intervention with comprehensive healthy lifestyle promotion improves blood pressure and some behavioural CVDRFs.

**Conclusion:** Alarming increases in CVDRFs in the general population need comprehensive multi-level prevention strategies, which combine both individual high-risk and population health approaches. The commune-based hypertension-centred management programmes integrated with community health promotion are the initial but essential steps towards comprehensive and effective management of CVDRFs and should be part of an integrated and co-ordinated national program on the prevention and control of chronic diseases in low-resource settings like Vietnam.

**Keywords:** cardiovascular disease risk factors, epidemiology, prevention, hypertension, Vietnam.
## Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>BMI</td>
<td>Body Mass Index</td>
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<tr>
<td>BP</td>
<td>Blood Pressure</td>
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<tr>
<td>CI</td>
<td>Confidence Interval</td>
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<tr>
<td>CHD</td>
<td>Coronary Heart Disease</td>
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<tr>
<td>CVD</td>
<td>Cardiovascular Disease</td>
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<tr>
<td>CVDRF</td>
<td>Cardiovascular Disease Risk Factor</td>
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<tr>
<td>DBP</td>
<td>Diastolic Blood Pressure</td>
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<tr>
<td>FilaBavi</td>
<td>Epidemiological Field Laboratory in Ba-Vi District, Hanoi, Vietnam</td>
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<tr>
<td>HDL-C</td>
<td>High-Density Lipoproteins Cholesterol</td>
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<tr>
<td>HIV/AIDS</td>
<td>Human Immunodeficiency Virus/Acquired Immune Deficiency Syndrome</td>
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<tr>
<td>LDL-C</td>
<td>Low-Density Lipoproteins Cholesterol</td>
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<tr>
<td>LMIC</td>
<td>Low- and Middle-Income Country</td>
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<td>MI</td>
<td>Myocardial Infarction</td>
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<tr>
<td>NCD</td>
<td>Non-Communicable Disease</td>
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<tr>
<td>p</td>
<td>p-value</td>
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<tr>
<td>PAD</td>
<td>Peripheral Artery Diseases</td>
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<tr>
<td>PAR</td>
<td>Population-Attributable Risk</td>
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<tr>
<td>SBP</td>
<td>Systolic Blood Pressure</td>
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<tr>
<td>SE</td>
<td>Standard Error</td>
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<tr>
<td>STEP</td>
<td>Stepwise Approach to Surveillance of Non-Communicable Risk Factors</td>
</tr>
<tr>
<td>USD</td>
<td>United States Dollar</td>
</tr>
<tr>
<td>VND</td>
<td>Vietnamese Currency “Dong” (1USD ≈ 21,000 VND in 2011)</td>
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<tr>
<td>VNHI</td>
<td>Vietnam National Heart Institute</td>
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<tr>
<td>WC</td>
<td>Waist Circumference</td>
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<tr>
<td>WHO</td>
<td>World Health Organization</td>
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<tr>
<td>WHR</td>
<td>Waist-Hip Ratio</td>
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Original Papers

This thesis is based on the following papers, which will be referred to in the text by their Roman numerals.


II. Nguyen NQ, Pham TS, Nguyen LV, Weinehall L, Bonita R, Byass P, Wall S. Time trends in blood pressure, body mass index and smoking in the Vietnamese population: a meta-analysis from multiple cross-sectional surveys. (Submitted)


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Introduction

Cardiovascular Diseases and Risk Factors

Cardiovascular disease (CVD) is the term to embrace diseases of the heart, vascular diseases of the brain and diseases of blood vessels. CVDs are responsible for over 17.3 million deaths per year in 2008 and remain the leading causes of death and disabilities in the world [1, 2], especially in low and middle-income countries (LMICs) where 80% of the total CVD burden occurs [3, 4]. The percentage of premature deaths from CVDs in LMICs was 42%, ten times higher than that in high-income countries, but both included more than 3 million deaths before the age of 60, of which the majority can be prevented [1, 5].

Lifelong development of atherosclerosis is the main cause of fatal and non-fatal CVDs such as coronary heart disease (CHD), cerebrovascular disease and peripheral vascular or aortic diseases. Among factors that promote the process of atherosclerosis known as CVD risk factors (CVDRFs), a few traditional modifiable CVDRFs explain about 90% of the population-attributable risks (PAR) of both myocardial infarction (MI) and stroke [6, 7], the top two major adverse cardiac events and causes of CVD deaths, although the PARs are different for stroke (with greater impacts of hypertension and lesser impacts of smoking, diabetes and lipids) compared with the PARs for MI (Table 1).

Table 1. Population-attributable risks [% (99%CI)] of major CVDRFs for MI and stroke in INTERHEART [6] and INTERSTROKE [7] studies

<table>
<thead>
<tr>
<th>Major CVDRFs</th>
<th>Acute MI</th>
<th>Stroke</th>
</tr>
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<tbody>
<tr>
<td>Hypertension</td>
<td>17.9 (15.7-20.4)</td>
<td>34.6 (30.4-39.1)*</td>
</tr>
<tr>
<td>Current smoking</td>
<td>35.7 (32.5-39.1)</td>
<td>18.9 (15.3-23.1)*</td>
</tr>
<tr>
<td>Apo-lipoprotein B/A1 ratio</td>
<td>49.2 (43.8-54.5)</td>
<td>24.9 (15.7-37.1)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>9.9 (8.5-11.5)</td>
<td>5.0 (2.6-9.5)</td>
</tr>
<tr>
<td>Abdominal obesity (WHR)</td>
<td>20.1 (15.3-26.0)</td>
<td>26.5 (18.8-36.0)*</td>
</tr>
<tr>
<td>Lack of vegetables/fruits diet</td>
<td>13.7 (9.9-18.6)</td>
<td>18.8 (11.2-29.7)*</td>
</tr>
<tr>
<td>No regular physical activity</td>
<td>12.2 (5.5-25.1)</td>
<td>28.5 (14.5-48.5)</td>
</tr>
<tr>
<td>Alcohol intake</td>
<td>6.7 (2.0-20.2)</td>
<td>3.8 (0.9-14.4)*</td>
</tr>
<tr>
<td>Psychosocial stress</td>
<td>32.5 (25.1-40.8)</td>
<td>9.8 (4.8-19.4)</td>
</tr>
<tr>
<td>Cardiac causes</td>
<td>-</td>
<td>6.7 (4.8-9.1)</td>
</tr>
<tr>
<td><strong>All combined</strong></td>
<td><strong>90.4 (88.1-92.4)</strong></td>
<td><strong>88.1 (82.3-92.2)</strong></td>
</tr>
</tbody>
</table>

* significant for haemorrhagic stroke only
These major CVDRFs in Table 1 include hypertension, abnormal lipids, diabetes mellitus, tobacco use, obesity, diets with low intakes of fruits and vegetables, physical inactivity, excessive alcohol intake and psychosocial factors, which can divided into two groups: metabolic and behavioural CVDRFs, both accumulated mutually and linked in a life-long complex web with clinical endpoints, novel risk factors and environmental determinants of health (Figure 1) [8-11].

Figure 1. Pyramid of multi-level CVDRFs, adapted from Mozaffarian D [10]

When CHD and stroke were assessed as major contributors to global mortality in 2008, (7.3 and 6.2 million deaths, respectively [12]), there were considerable country-to-country variations in the burden of stroke versus CHD as well as variations in the relative contributions of CVDRFs over the world [13-19]. Lower national income, hypertension, heavy alcohol intake and advancing age were associated with higher stroke burden but smoking, dyslipidaemia, diabetes were linked to higher CHD burden, both highlighting the findings that CHD and stroke burden did not track uniformly and the differences in CVD burdens in each country required corresponding strategies/approaches in their own settings [19]. Along the various stages of epidemiological transition, inadequate health care resources in budget-constrained settings may directly impact on the stroke burden more than the CHD burden [20, 21]. Compared to other wealthier countries, in 7 Asian countries (except India) and other African and American LMICs, stroke is more prominent than CHD, probably due to a higher prevalence of hypertension and a lower prevalence of dyslipidaemia, both accompanying
traditional habits of higher salt and lower fat intake as in the typical example of China [22]. However, recent westernization in the Asian region has increased fat and high-calorie food consumption, followed by faster peaking of the prevalence of obesity, dyslipidaemia and diabetes than elsewhere [23-28]: all these will make the CHD burden increase in addition to the existing stroke burden.

Progression of CVDs is a continuum, which requires lifelong prevention across all stages of disease development (Figure 2) [29]. Starting at the earliest stages of life (either genetically or in the perinatal period), and potentially interacting and accumulating through the life span [30], CVDRFs should be tackled by a sequence of preventive strategies including primordial, primary and secondary prevention, all of which should be combined flexibly and appropriately to reduce the CVD burden (morbidity and mortality), reducing recurrences and incidence and improving quality of life. Primordial prevention is focused on population improvement of socioeconomic and environmental health determinants to delay CVDRFs. Primary prevention is focused on CVDRF control using both population-based and clinic-based strategies while secondary prevention involves individual acute and chronic management or rehabilitation for CVDs.

**Figure 2.** Pyramid of CVD prevention, adapted from Gupta R [29]

Although high-risk people benefit more from preventive measures, CVD events occur more in low or medium-risk groups, which account for a higher proportion of the population [31]. Therefore, CVDRF prevention requires two complementary strategies: (i) a population (or public health) approach targeting the entire community to shift the CVDRF distribution in a
favourable direction by population interventions, which are relatively low cost, but require extensive health education combined with national or policy-level measures, and (ii) a high-risk (or clinical) approach to identify and manage individuals at highest risk through healthcare systems, using cost-effective integrated methods, then reducing their susceptibility by multi-drug combinations [32-35].

**CVD Burden in Vietnam**

Vietnam has experienced a shift in mortality patterns from communicable to non-communicable diseases along with increasing longevity and an ageing population [36-39], resulting in a double financial burden from the established high burden of persistent infections (including the emerging burden of chronic infection such as HIV or tuberculosis) and the escalating burden of chronic diseases, especially CVDs. Similarly to other LMICs, stroke is more prominent than coronary heart disease in Vietnam, both accounting for nearly a quarter of total deaths [40]. A national population-based verbal autopsy survey showed that stroke-related mortality was five times as high as CHD-related deaths [39], which put stroke as the leading cause of death for both men and women, ranking first for men and second for women among the top causes of total disease burden in 2008 [40]. While CVDs were the largest contributor to the total burden of disease in Vietnam, the contribution of stroke and CHD was similar among men and women [40]. Stemming from environmental factors and unhealthy lifestyles, this emerging problem burdens families, impacts on the entire economy and social development, threatens the lives and health of millions of people, and compromises sustainable development efforts and poverty reduction initiatives [4, 27, 41]. However, the country had inadequate health system capacity (including monitoring and surveillance operations nationally) to effectively deal with the costly and complex clinical challenges of rapid rises in non-communicable diseases like CVDs and cancers [4, 42].

**Challenges for Cardiovascular Disease Prevention**

While CVD mortality in many richer countries has substantially reduced over the last few decades, CVD death rates in poorer countries are already higher and are rising [27, 43, 44]. CVD modelling from developed countries suggests that great reductions in mortality resulted from improving the CVDRF distribution in the population or enabling higher proportions of the population to receive evidence-based treatments [45]. The actual benefits would double if all eligible CVD patients could receive appropriate therapies at the right time [46]. However reductions in the prevalence of major CVDRFs, even modestly, had already accounted for more than twice as many
life-years gained as the treatments did [47, 48]. Favourable changes in CVDRFs such as smoking cessation and aggressive treatment of metabolic CVDRFs almost halved CVD mortality, separately from earlier diagnosis and life saving treatment [49, 50]. Three very cost-effective interventions in primary care are tobacco control, salt reduction and a multidrug strategy to treat people who are at high CVD risk [32, 51, 52]. Recently, more evidence emphasised the importance and effectiveness of interventions to tackle unhealthy diets, physical inactivity and obesity as well as policy-level solutions to create favourable healthy environments [52-55]. However, inadequate healthcare resources, insufficient access to healthcare services, physician inertia and “political failure” are main barriers to widely implementing these proven cost-effective interventions in the primary healthcare system [55-57].

Lessons and successful experiences from chronic HIV/AIDS epidemics can be usefully applied to the prevention and control of CVD [58]. Good surveillance systems for CVD and CVDRFs are crucial for measuring the problem’s magnitude and costs, identifying vulnerable groups, and evaluating intervention effects [58]. Low-cost detection approaches should be linked to cost-effective prevention and treatment that efficiently integrate behavioural and biomedical approaches (or public health and health care resources) [58, 59]. As in HIV/AIDS, besides the individual behavioural interventions and societal policies for healthier lifestyles, which mainly affected the most motivated adopters, it is critical to integrate low-cost biomedical interventions into CVD prevention as a complementary part of a holistic approach [58, 60]. To avoid costly therapies at more advanced stages, there will be overwhelming demands for wide availability of early detection and effective care and preventive services concurrently, which require prioritizing the development of delivery and financing models for integrated health systems and ensuring that supplies meet the demand [58].

In many LMICs, the existing healthcare systems confront the lack of resources, the low priority of CVD in systems geared towards acute and infectious care, and the lack of an integrated infrastructure involving communities, health services and local institutions [18, 61]. For prevention of CVD in LMICs, three urgent challenges must be met: (i) a redesigned primary care network with broad universal access; (ii) a surveillance system for key modifiable risk factors using repeated cross-sectional surveys, population-based cohorts or vital registration; (iii) a framework for social engagement, developing and implementing health policy to establish healthy living environments [18, 61]. Three relevant staircases of prevention are: (i) societal and policy levels (to address the upstream social determinants of health); (ii) health system level (comprehensive and integrated primary
healthcare); (iii) individual level (primary and secondary prevention or acute management) (Table 2) [62, 63].

Table 2. 3-level public health interventions, modified from Franco M [63]

<table>
<thead>
<tr>
<th>CVDRFs</th>
<th>Societal/policy level: built environments</th>
<th>Health system level</th>
<th>Individual level: behavioural change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smoking</td>
<td>- Tobacco tax/law</td>
<td>- Primary care programmes for smoking cessation</td>
<td>- Avoiding smoking uptake by young -Smoking cessation</td>
</tr>
<tr>
<td>Physical inactivity</td>
<td>- Recreational facilities</td>
<td>- Primary care programmes for increasing physical activity</td>
<td>- Promotion of physical activity -Leisure versus utilitarian activity</td>
</tr>
<tr>
<td>Unhealthy dietary patterns</td>
<td>- Making vegetables and fruits more available, cheaper</td>
<td>- Primary care unit or programmes for improving dietary quality</td>
<td>Nutritional education on TV and in schools</td>
</tr>
<tr>
<td>Metabolic CVDRFs</td>
<td>- See the above interventions</td>
<td>- Primary care unit (multi-disciplinary) to manage and control body weight, blood lipids and glucose levels, BP</td>
<td>- Nutritional education -Physical activity programmes -Develop home BP monitoring programmes</td>
</tr>
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</table>

Conceptual Framework

The conceptual framework for this thesis is based on a dynamic, complex web of factors, in which adverse CVD endpoints are linked with health determinants and behavioural risk factors, and mediated through metabolic risk factors. CVDRFs can evolve intrinsically or be influenced by intentional health interventions. The two following themes are considered: (i) a epidemiological perspective on how CVDRFs progress over time and burden the general population and (ii) a prevention perspective on how CVDRFs can be influenced by community health interventions.
These themes are summarised in Figure 3 and covered by two chapters: the first chapter will describe the CVDRF patterns and progression in the general population while the following chapter will describe community-based interventions and the impacts of comprehensive lifestyle promotion on CVDRFs in a rural setting. Other chapters will discuss methodological issues, leading to conclusions and recommendations.

**Figure 3.** Conceptual framework for the study on the CVDRF progression
Objectives

Overall Objectives

The overall objective of this study is to investigate the natural progression of CVDRF patterns and impacts of community-targeted health interventions in the general adult population of Vietnam. The ultimate goal of the study is to contribute to the development and the optimization of future community-based health interventions for CVDRFs and consequently reduce their emerging epidemic burden in Vietnam and similar settings.

Specific Objectives

1. To estimate the magnitude of CVDRFs and to identify CVDRF patterns in the general adult population of Vietnam (I).

2. To explore the progression over time of CVDRFs in the general adult population of Vietnam (I, II)

3. To describe a model of community-targeted intervention incorporating comprehensive healthy lifestyle promotion campaigns integrated into a commune-based hypertensive-targeted programme on hypertension management by multidrug therapy (III).

4. To evaluate the effectiveness of the community-based comprehensive health promotion on the pattern of CVDRFs in the general adult population of a rural area in Vietnam (IV).

Main findings from four papers (I-IV), listed in page v, and additional analysis of data from the above-mentioned original studies are presented and summarized according to the themes in the conceptual framework (Figure 3).
Materials and Methods

Study Settings and Designs

Study Settings

The studies in this thesis were conducted in two settings: (i) the national setting, based on eight provinces, which were representative of four geographical areas from northern and southern regions of Vietnam, where epidemiological surveys (study 1, 2) were done and (ii) a local setting incorporating two communes (Phu-Cuong and Phu-Phuong) from Ba-Vi district, Ha Tay province, where community-based intervention studies were done (study 3).

Figure 4. Study settings for the thesis

The setting for national level epidemiological surveys included 8 provinces randomly selected to be representative of city and three other geographical areas (lowland, highland and coastal) in the northern and southern part of Vietnam [64] (Figure 4). This setting was initiated by Vietnam National Heart Institute (VNHI) for the national survey on hypertension and its risk factors including diabetes (NESH), and subsequently used for the survey on heart failure and its risk factors in 4 northern provinces (HP-S) and the survey on diabetes and its risk factors in 2 northern provinces (DM-S). All these studies were designed and carried out by the VNHI core team.
The local setting for community-based intervention studies was two lowland communes (Phu-Cuong and Phu-Phuong) from Ba-Vi district, Ha-Tay province. Ba-Vi is a typical rural area, 60 km west of Hanoi, with a population of about 260,000 (2010 data) covering an area of 410 km², including lowland, highland and mountainous areas, experiencing a typical climate for northern Vietnam (predominantly a monsoon tropical climate with two wet and dry seasons). Agricultural production and livestock breeding were the main economic activities of the local people (81%), with major products being wet rice, cassava, corn, soybean, green beans and some fruit. Illiteracy was reportedly only for 0.4% of the adult population. The average income per person per year was around 48 USD in 1996 and increased to 750 USD in 2010. This district had already been purposively selected for a longitudinal population-based demographic surveillance FilaBavi (Field Laboratory for health system research) under a collaboration between the Health Strategy and Policy Institute, Hanoi Medical University and Swedish institutions (including the Division of International Health IHCAR, Karolinska Institute, Stockholm; the Division of Epidemiology and Global Health, Umeå University, Umeå and the Nordic School of Public Health, Gothenburg) [65].

**Study designs and data collection**

![Study Designs Diagram](image)

**Figure 5.** Overview of the study timeline for the all studies in the thesis

Cross-sectional study designs were used for all epidemiological surveys reported in this thesis to assess the major CVDRFs in the general population from 2001 to 2009, including some national-level surveys mentioned above (NESH, HF-S, DM-S) or the local survey on non-communicable disease risk factors in FilaBavi (NCDS) [66, 67] and some local screening surveys from the hypertension management project in rural communes (HMPS). All of these studies used the same protocol from the VNHI core team despite a few differences in sampling strategy (Table 1 paper II). Data from the DM-S
survey was used to evaluate CVDRF burden in the general adult population (study 1). An individual participant-level collated dataset from all of these yearly cross-sectional surveys (including DM-S) was used to identify the time trends of CVDRFs in the general adult population (study 2). Figure 5 summarizes the timeline of all studies in the thesis.

![Figure 5](image)

**Figure 6.** Design of the quasi-experimental intervention study

Study 3 used a quasi-experimental design to evaluate the impact of community-based health promotion on CVDRFs in the general population in a rural setting (Figure 6). Two communes were purposively selected from Ba-Vi district: Phu-Phuong for reference and Phu-Cuong for intervention. A hypertension management programme nested with comprehensive health promotion campaigns was implemented simultaneously in Phu-Cuong while no programme was launched in Phu-Phuong, which retained local conventional healthcare services. The health promotion campaigns aimed at smoking cessation, reduction of alcohol consumption, encouragement of healthier less-salty diets and physical activity, all of which were targeted at all local people. The hypertension management programme focused on monthly check-ups, drug delivery and individual lifestyle consultations, all of which were targeted at hypertensives only. Repeated cross-sectional surveys (the baseline survey in 2006 and one after the 3-year intervention in 2009) were used to assess the changes in CVDRFs in the local communities to find out the impact of the health promotion campaigns (paper IV). The impact of the hypertension management programme on blood pressure (BP) control was evaluated separately by another cohort study following the same
participants with high BP detected from two baseline surveys (Figure 6). All steps to implement the management programme and data from the early follow-up of hypertensives in the intervention commune were described and analysed in paper III.

In all cross-sectional surveys, random sampling strategies were applied to recruit representative samples for the studied populations. The same multi-stage stratified sampling methods were used in national surveys (NESH, HF-S and DM-S), in which 4 districts per province and 3 communes per district were randomly chosen. Then 110 persons were randomly selected from a list of all inhabitants in each randomized commune (as primary sampling units). In NCDS, sex and age group stratified random sampling was used with 250 persons per 10-year age group per sex [66, 67]. In HMPS and the all pre and post intervention surveys of study 3, simple random selection was used to select candidates from the list of all adult inhabitants in the local area, which possibly excluded a certain number of males who migrated out for economic reasons. Being initiated in NESH, the assumed sample size of 1,200 in each surveyed area was large enough to identify prevalence of both hypertension and diabetes in the general adult population accounting for a theoretical design effect of 2 (for multi-stage sampling). This sample size was followed by all surveys except NCDS with specific sampling strategy and bigger sample size (Table 1, paper II).

Data were collected at local health stations in each surveyed commune by well-trained surveyors. The STEPwise-based questionnaire [68, 69] was used to report behavioural CVDRFs, demographic background and medical history. An identical protocol [64] was applied to get anthropometric and BP measurements using standardized devices. In some surveys (DM-S or NESH [for one fifth of sample in cities] [64]), fasting participants were asked to have an oral glucose tolerance test with 75g glucose and a blood sample for lipid profiles (paper I). The VNHI team supervised all steps to guarantee the study quality and maintain an identical workflow through all surveys.

In addition to the quantitative surveys, a qualitative study was also carried out in Ba-Vi district to explore how people formulated their conceptions about CVDRFs, using thematized focus group discussions and content analysis approaches. Totally eight convenience-sampled group discussions were conducted (5-6 adults per group, separately for each sex, age group [25-64 years vs. ≥ 64 years] and living conditions [rural vs. semi-urban area]).

An overview of the four papers, in terms of study objectives, data sources, study sample, main variables and outcomes is given in Table 3. Paper I and II mainly addressed the epidemiological themes such as within-individual
clustering patterns and the time trends of CVDRFs in the general population. Paper III and IV addressed the prevention theme through a commune-based programme on hypertension management, focusing on hypertension and behavioural CVDRFs in rural settings. Paper III was mainly descriptive highlighting the implementation of the programme in a low-resource setting while paper IV was more analytical and addressed the effects of community health promotion interventions on blood pressure and behavioural CVDRFs.

**Table 3.** Overview of the designs of the four papers included in the thesis

<table>
<thead>
<tr>
<th>Paper</th>
<th>Specific objective</th>
<th>Study designs and data collection methods</th>
<th>Sample size</th>
<th>Main variables or outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Pattern of CVDRFs in population (2009)</td>
<td>Cross-sectional surveys on diabetes and its risk factors</td>
<td>2,130 adults (aged ≥25) from DM-S (2 provinces)</td>
<td>Clustering of behavioural and metabolic CVDRFs for each sex or area</td>
</tr>
<tr>
<td>II</td>
<td>Time trend of major CVDRFs in population from 2001 to 2009</td>
<td>Individual participant-level meta analysis from multiple cross-sectional surveys</td>
<td>23,563 adults (aged 25-74) from NESH, HF-S, DM-S, NCDS, HPMS (9 provinces)</td>
<td>Blood pressure, smoking and body size: progression over time for each sex or area</td>
</tr>
<tr>
<td>III</td>
<td>Process to setup a BP management model in a rural area from 2006 to 2008</td>
<td>17-month cohort study on patients of the model of hypertension management at Phu-Cuong commune, Ba-Vi</td>
<td>497 adults (age ≥25) patients treated by the model</td>
<td>Factors influenced the adherence to the model of hypertension management at rural commune</td>
</tr>
<tr>
<td>IV</td>
<td>Impact of health promotion on CVDRFs in rural settings from 2006 to 2009</td>
<td>Quasi-experimental community health intervention in one reference and one intervention commune in Ba-Vi, evaluated by repeated cross-sectional surveys</td>
<td>4,645 adults (age ≥25) in four surveys pre and post in reference and intervention areas</td>
<td>Changes in behavioural CVD RFs and blood pressure: after 3-year intervention compared between reference and intervention areas</td>
</tr>
</tbody>
</table>
Main Variables

Occupational status was classified into 3 groups: government staff, manual workers (farmers, building workers, etc.) and other (housewives, jobless, disabled). Educational level, which was determined by years of schooling, was classified into 2 groups: incomplete secondary schooling (≤9 years of education) and higher (>9 years of education including high school or higher). Residential area consisted of urban and rural, which was identified on an administrative basis for each commune within each province.

Table 4. Main definition of behavioural CVDRFs in the thesis

<table>
<thead>
<tr>
<th>CVDRFs</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current smoking</td>
<td>Smoking tobacco products such as cigarettes, cigars or pipes over the previous month [69]</td>
</tr>
<tr>
<td>Heavy alcohol consumption</td>
<td>Having more than 2 standard units of drink per day (in women) or more than 3 per day (in men) [69]</td>
</tr>
<tr>
<td>Low vegetable or fruit</td>
<td>Having on average less than five standard servings of fruit and/or vegetables per day [69]</td>
</tr>
<tr>
<td>or fruit consumption</td>
<td></td>
</tr>
<tr>
<td>Salty diet</td>
<td>Having self-reported preference for daily foods that contained more salt than the similar foods chosen by other adult members in the family or people around them</td>
</tr>
<tr>
<td>Unhealthy diet</td>
<td>Having either salty diet or diet with low fruit and vegetable consumption</td>
</tr>
<tr>
<td>Physical inactivity</td>
<td>Having total physical activity less than 3,000 metabolic equivalents (METs) minutes per week, which were estimated based on details of duration and type of all self-reported physical activities in a typical week [69]</td>
</tr>
<tr>
<td>Experiencing psychosocial</td>
<td>Having more than 2 moderate stressors, which were semi-quantified by some simple questions to evaluate any stress at work or at home, financial stress, major life events (marital separation/divorce, loss of crop/job, major intra-family conflict, death, illness of a close family member/spouse) or any major stress in the past year at different levels (none, mild, moderate and severe) [6].</td>
</tr>
<tr>
<td>stress</td>
<td></td>
</tr>
</tbody>
</table>

Behavioural CVDRFs included current smoking, heavy alcohol consumption, unhealthy diet, physical inactivity and experiencing stress (Table 4). Metabolic CVDRFs included hypertension, abnormal lipids, obesity, and diabetes mellitus (Table 5). People who had ≥ 2/4 metabolic CVDRFs, ≥ 2/5 behavioural CVDRFs or total ≥ 4/9 of all metabolic and behavioural CVDRFs
were considered to have individual clusters of respective CVDRFs. Ideal Cardiovascular Health was defined as the simultaneous presence of 4 favourable behavioural CVDRFs (no smoking, ideal BMI <23 kgm⁻², regular physical activity, healthy diet) and 3 favourable metabolic CVDRFs (untreated total cholesterol <5.17 mmol/l, untreated blood pressure <120/80 mmHg, fasting blood glucose <5.5 mmol/l) without any clinical CVD (CHD, stroke, heart failure, etc.) [70].

Table 5. Main definition of metabolic CVDRFs in the thesis

<table>
<thead>
<tr>
<th>CVDRFs</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overweight</td>
<td>Having body mass index (BMI) ≥23, which was calculated as weight (kg) divided by height squared (m²) [71]</td>
</tr>
<tr>
<td>Obesity</td>
<td>Having BMI ≥25 or having central obesity (BMI ≥23 with waist circumference ≥90 cm in men or ≥80 cm in women), as was specified for South-Asian populations [71]</td>
</tr>
<tr>
<td>Hypertension</td>
<td>Having an average systolic BP (SBP) ≥ 140 mmHg or average diastolic BP (DBP) ≥ 90 mmHg or having self-reported current antihypertensive treatment [72-74]</td>
</tr>
<tr>
<td>Controlled hypertension</td>
<td>Having pharmacological treatment resulting in an average SBP &lt; 140 mmHg and DBP &lt; 90 mmHg [64]</td>
</tr>
<tr>
<td>Dyslipidaemia</td>
<td>Having self-reported current cholesterol-lowering treatment or having at least one following criteria: total cholesterol ≥ 5.17 mmol/l; HDL-C&lt; 1.03 mmol/l; LDL-C ≥ 3.36 mmol/l and triglyceride ≥ 1.7 mmol/l [75]</td>
</tr>
<tr>
<td>Controlled dyslipidaemia</td>
<td>Having pharmacological treatment resulting in LDL-cholesterol &lt; 3.36 mmol/l (for general population) [75]</td>
</tr>
<tr>
<td>Diabetes</td>
<td>Having fasting plasma glucose ≥ 7.0 mmol/l or plasma glucose 2h-post oral glucose tolerance test ≥ 11.1 mmol/l or having self-reported current diabetes treatment [76-78]</td>
</tr>
<tr>
<td>Controlled diabetes</td>
<td>Having pharmacological treatment resulting in HbA1C &lt; 7.0% and fasting plasma glucose &lt; 7.0 mmol/l [78]</td>
</tr>
</tbody>
</table>

The overall 10-year risk of developing coronary heart disease (MI, coronary death) and other important adverse cardiac events (stroke, heart failure) in people aged 30-74 years without baseline CVDs was estimated by the Framingham general cardiovascular risk score using the following variables: age, sex, current smoking, treated and untreated SBP, diabetes, and lipid profile (total cholesterol, HDL-C) or BMI (replacing lipids if blood test was unavailable). People with overall CVD 10-year risk ≥20% were classified as having a high overall CVD risk [79].
Statistical Methods

The mean levels or prevalence of each CVDRF were presented as means ± standard errors (SE) or proportions with 95% confidence intervals (CI), standardized for age structure and sex. In the study of CVDRF time trends, age distribution for each surveyed province from the Vietnam Population and Housing Census in 2009 [80] was used to weight and age-standardise for the prevalence or mean level of each CVDRF so that the adjusted values for each year could be comparable over time.

Univariate ANOVA tests were used to identify significant differences among these prevalence or mean levels of CVDRFs between comparable groups. Impacts of explanatory variables on the outcome were considered using multivariable linear or logistic regression models. Multilevel mixed-effect models were used to manage the potential heteroskedasticity and the cluster effect among surveys. Interactions between some explanatory variables were added to the model to identify the specific difference in time trends (study 2) or the differences-in-differences (i.e. impact) of intervention (study 3).

A p-value < 0.05 was considered to represent statistical significance. Both descriptive and analytical statistical analyses were carried out using STATA 11 software (Stata Corporation®, Texas, USA).

Ethical Considerations

The protocols of each survey were approved by Scientific Ethical Committee for Biomedical Research at the Vietnam National Heart Institute (VNHI) and at the corresponding involved partners. The protocol for the community-based intervention study was approved by Scientific Ethical Committees for Biomedical Research at the Ministry of Health, at VNHI and also by the People’s Committee of Ba-Vi district, Ha-Tay province.

All human subjects in any surveys were asked for their written consent before the collection of data or their acceptance for giving blood sample. Any participants with hypertension or other disorders detected during the surveys were referred to appropriate facilities for further investigation and treatment. In the quasi-experimental intervention study, any patients detected with hypertension in the reference commune were referred for conventional care and treatment, while all detected patients in the intervention commune were invited to join the newly initiated local programme on hypertension management to get monthly check-ups and drug provision during the study period. All participants had complete rights to withdraw from any study at any time without any threat or disadvantage.
An Epidemic of CVDRF in Vietnam

Changes Over Time in Major CVDRFs in the General Population

Results from the 9-year meta-analysis show increasing trends over time in BP (both SBP and DBP) and body size (weight and waist circumference) in the population of Vietnam aged 25-74 years (Table 6, Figure 7). On average, the SBP and DBP increased 0.9 and 0.4 mmHg per year, similarly between men and women and between rural and urban areas (paper II).

Table 6. Estimated annual changes (95% CI) of blood pressure and body size in the general population, by sex and residential area (study 2)

<table>
<thead>
<tr>
<th>Annual changes during 2001-2009</th>
<th>Rural area</th>
<th>Urban area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Women</td>
<td>Men</td>
</tr>
<tr>
<td>Mean systolic BP (mmHg)</td>
<td>0.7</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>0.5-0.9</td>
<td>0.8-1.3</td>
</tr>
<tr>
<td>Mean diastolic BP (mmHg)</td>
<td>0.4</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>0.3-0.5</td>
<td>0.4-0.7</td>
</tr>
<tr>
<td>Men weight (kg)</td>
<td>0.3</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>0.3-0.4</td>
<td>0.5-0.7</td>
</tr>
<tr>
<td>Mean waist circumference (cm)</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>0.5-0.7</td>
<td>0.5-0.7</td>
</tr>
</tbody>
</table>

Figure 7a. Time trends of systolic blood pressure in the general population
The average weight and waist circumference increased 0.4 kg and 0.5 cm per year respectively, with similar trends in men and women and faster in rural than in urban areas. Consequently, the prevalence of hypertension and
obesity in adults annually increased by 0.9 and 0.3% in women, 1.1 and 0.9% in men with similar time trends in both rural and urban areas (paper II). While smoking did not reduce over time in men, the progression of average blood pressure and weight in the population resulted in an increase of overall CVD 10-year risk of 0.2% in women and 0.4% in men. This rate was higher in men than in women and higher in urban than in rural areas (Figure 8). In a span of less than 10 years (2001-2009), our data showed that the increase in SBP and BMI in the Vietnamese general population far exceeded the global estimation of changes in these CVDRFs for Southeast Asian region [81-83]. Combined with smoking, which was unchanged during this period and other CVDRFs, which often clustered at individual level (paper I), without prompt reactions these trends would rapidly lead to a catastrophic projected CVD epidemic after a short time lag and threaten national wealth [84, 85].

Figure 8. Time trend of overall CVD 10-year risk, estimated by BMI-based Framingham general cardiovascular risk score in the general population

Changes With Age and Clustering of CVDRFs in Adults

Results from the most recent general population survey (paper I) showed that each CVDRF was more common in men than in women except for physical inactivity and experiencing stress (Table 7). CVDRFs were often individually clustered, increasing with age by sex-different patterns (Figure 9).
Table 7. Prevalence of CVDRFs (± SE) in the general population in 2009, stratified by sex and residential area (study 1)

<table>
<thead>
<tr>
<th>CVDRFs</th>
<th>Rural area</th>
<th></th>
<th>Urban area</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Women</td>
<td>Men</td>
<td>Women</td>
</tr>
<tr>
<td>Hypertension</td>
<td>17.3 ± 1.5</td>
<td>26.2 ± 2.3</td>
<td>30.8 ± 1.8</td>
<td>35.5 ± 2.8</td>
</tr>
<tr>
<td>Diabetes</td>
<td>3.8 ± 0.8</td>
<td>7.4 ± 1.4</td>
<td>8.0 ± 1.1</td>
<td>8.5 ± 1.6</td>
</tr>
<tr>
<td>Obesity</td>
<td>6.3 ± 0.9</td>
<td>4.3 ± 1.0</td>
<td>25.8 ± 1.8</td>
<td>23.3 ± 2.7</td>
</tr>
<tr>
<td>Dyslipidaemia</td>
<td>44.6 ± 2.2</td>
<td>55.0 ± 2.8</td>
<td>58.2 ± 2.1</td>
<td>69.7 ± 3.0</td>
</tr>
<tr>
<td>≥ 2/4 metabolic CVDRFs</td>
<td>16.1 ± 1.5</td>
<td>21.9 ± 2.2</td>
<td>37.0 ± 2.0</td>
<td>41.0 ± 3.0</td>
</tr>
<tr>
<td>Current smoking</td>
<td>2.6 ± 0.7</td>
<td>61.7 ± 2.6</td>
<td>4.6 ± 0.8</td>
<td>56.3 ± 3.1</td>
</tr>
<tr>
<td>Excessive alcohol intake</td>
<td>1.0 ± 0.4</td>
<td>26.6 ± 2.5</td>
<td>0.9 ± 0.4</td>
<td>28.5 ± 2.8</td>
</tr>
<tr>
<td>Unhealthy diet</td>
<td>66.8 ± 2.0</td>
<td>66.5 ± 2.6</td>
<td>40.9 ± 2.1</td>
<td>53.2 ± 3.1</td>
</tr>
<tr>
<td>Physical inactivity</td>
<td>3.6 ± 0.7</td>
<td>5.7 ± 1.2</td>
<td>31.1 ± 2.0</td>
<td>32.9 ± 2.9</td>
</tr>
<tr>
<td>Having stress</td>
<td>31.3 ± 2.0</td>
<td>26.9 ± 2.4</td>
<td>24.0 ± 1.9</td>
<td>20.6 ± 2.6</td>
</tr>
<tr>
<td>≥ 2/5 behaviour CVDRFs</td>
<td>29.1 ± 2.0</td>
<td>62.4 ± 2.6</td>
<td>25.4 ± 1.9</td>
<td>61.6 ± 3.0</td>
</tr>
<tr>
<td>≥4/9 major CVDRFs</td>
<td>6.1±1.0</td>
<td>25.6±2.3</td>
<td>18.2±1.6</td>
<td>42.1±3.1</td>
</tr>
</tbody>
</table>

Figure 9. Changes of number of clustered CVDRFs with age in the general population in 2009, stratified by sex and residential area (study 1)
Among behavioural CVDRFs, having stress reduced while unhealthy diet or physical inactivity remained unchanged with age in both sexes. Smoking and excessive alcohol intake was traditionally male-dominated but also reduced with age. The number of behavioural CVDRFs in men reduced with age but was always higher than the number in women (Figure 9) (Table 2, paper I).

All four metabolic CVDRFs increased with age in women while in men only diabetes and hypertension increased. The age of 55 can be considered as an inflection point where the increasing trend of clustered metabolic CVDRF in women crossed and surpassed the trend in men, especially in urban areas (Table 2 & 4, paper I). This also highlighted a neglected subgroup of elderly women with alarming increases in clustered metabolic CVDRFs (Figure 9). Having more CVDRFs resulted in a higher overall CVD 10-year risk, regardless of sex or residential area (Figure 10).

Figure 10. Proportional relationship between number of CVDRFs and overall CVD 10-year risk, estimated by lipid profile-based Framingham general cardiovascular risk score

Estimation from study 1 showed that clustered major CVDRFs were found in 13.0% of women and 34.4% of men of the general population of Vietnam. These findings raised more concerns about cardiovascular population health, with the total proportion of ideal cardiovascular health in population only consisting of 7.3%, being especially low in men where smoking or heavy alcohol consumption was prevalent (1.7% in men versus 10.2% in women (Table 8). Our analysis in paper II also highlighted that urban living
conditions were significantly related to a higher prevalence of metabolic disorders after adjusting for age and other social factors [86-88].

**Table 8.** Prevalence of clustered CVDRFs in the general population in 2009, stratified by sex and residential areas (summarized from study 1)

<table>
<thead>
<tr>
<th>Area</th>
<th>Sex</th>
<th>Major CVDRFs</th>
<th>Ideal Cardiovascular Health</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
<td>6.1 ± 1.0</td>
<td>12.0 ± 1.5</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>25.6 ± 2.4</td>
<td>2.3 ± 0.8</td>
</tr>
<tr>
<td>Rural</td>
<td>Female</td>
<td>18.2 ± 1.6</td>
<td>8.8 ± 1.3</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>42.1 ± 3.1</td>
<td>1.0 ± 0.6</td>
</tr>
<tr>
<td>Urban</td>
<td>Female</td>
<td>13.0 ± 1.0</td>
<td>10.2 ± 1.0</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>34.4 ± 2.0</td>
<td>1.7 ± 0.6</td>
</tr>
</tbody>
</table>

**Gaps Between Burden And Management Capacity of CVDRFs**

Hypertension, diabetes and dyslipidaemia are routinely treated by multiple drug therapy and lifestyle consultation in the existing Vietnamese health care system but not in primary health care. Our meta-analysis showed a clear trend in improvement of awareness, treatment and control of hypertension through the years 2001-2009 but highlighted the gaps between the potential burden of CVDRFs and the real awareness or capacity to solve these in the community, which were even bigger in rural areas (Table 3, paper II).

**Table 9.** Prevalence (± SE) of awareness, treatment and control among people who have hypertension, diabetes, dyslipidaemia or at least ≥1/3 mentioned metabolic disorders in the general population in 2009 (study 1)

<table>
<thead>
<tr>
<th></th>
<th>Residential area</th>
<th>Hypertension</th>
<th>Diabetes</th>
<th>Dyslipidemia</th>
<th>Metabolic disorders</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Awareness</strong></td>
<td>Rural</td>
<td>30.5 ± 3.0</td>
<td>22.5 ± 5.8</td>
<td>3.4 ± 0.8</td>
<td>14.0 ± 1.4</td>
</tr>
<tr>
<td></td>
<td>Urban</td>
<td>36.6 ± 2.6</td>
<td>44.5 ± 5.4</td>
<td>13.8 ± 1.4</td>
<td>26.8 ± 1.7</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>34.6 ± 2.0</td>
<td>37.3 ± 4.2</td>
<td>9.8 ± 0.9</td>
<td>21.8 ± 1.2</td>
</tr>
<tr>
<td><strong>Treatment</strong></td>
<td>Rural</td>
<td>19.6 ± 2.5</td>
<td>22.5 ± 5.8</td>
<td>1.2 ± 0.5</td>
<td>9.3 ± 1.1</td>
</tr>
<tr>
<td></td>
<td>Urban</td>
<td>30.2 ± 2.4</td>
<td>43.5 ± 5.4</td>
<td>3.0 ± 0.6</td>
<td>18.6 ± 1.4</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>26.7 ± 1.8</td>
<td>36.6 ± 4.2</td>
<td>2.3 ± 0.4</td>
<td>15.0 ± 1.0</td>
</tr>
<tr>
<td><strong>Control</strong></td>
<td>Rural</td>
<td>4.1 ± 1.3</td>
<td>13.2 ± 4.7</td>
<td>0.9 ± 0.4</td>
<td>3.2 ± 0.7</td>
</tr>
<tr>
<td></td>
<td>Urban</td>
<td>6.4 ± 1.3</td>
<td>15.9 ± 3.7</td>
<td>2.1 ± 0.5</td>
<td>6.2 ± 0.8</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>5.7 ± 1.0</td>
<td>15.0 ± 2.9</td>
<td>1.6 ± 0.3</td>
<td>5.0 ± 0.6</td>
</tr>
</tbody>
</table>

In 2009, although being the most common among 3 metabolic disorders, the prevalence of awareness, treatment for dyslipidaemia were lowest (Table 9).
Only a minority of people diagnosed with hypertension, diabetes or dyslipidaemia achieved targeted outcomes (5.7%, 15.0% or 1.6% respectively (Table 9). This situation became even worse when diagnosis lagged far behind prevalence although the management of these disorders likely improved over time (paper II, I). Consequently, very little proportion of the adult population with high overall CVD risk (1.9%) had received optimal treatment for all metabolic disorders. The proportion of being treated at least 1/3 mentioned metabolic disorders in 2009 only consisted of 9.6% in the general population (5.3% in rural versus 13.1% in urban area), far behind the treatment demand for three main metabolic disorders (Figure 11).

![Figure 11](image)

**Figure 11.** Gaps between having and being treated for at least one among three disorders including hypertension, diabetes and dyslipidaemia in 2009

While the modifiable CVDRFs increased in the region due to globalisation [89], unplanned urbanisation, marketing of unhealthy food, and inadequacies in public health policies [18], access to medical care was a common barrier for people needing effective CVDRF management, especially in rural low-resource settings where local cardiac care capacity was insufficient. Self-treatment for common mild illness [90], no treatment for asymptomatic metabolic disorders and higher hospitals for advanced stages of disease (Table 10) were the main options for seeking healthcare.
rather than local commune health care station even though costly medical care services can easily lead to a “poverty trap” [91].

Table 10. Healthcare access for treating at least one metabolic disorder including hypertension, diabetes and dyslipidaemia in 2009 (study 1)

<table>
<thead>
<tr>
<th>Area</th>
<th>Sex</th>
<th>Self-treatment</th>
<th>Commune Health Station</th>
<th>Private Clinics or Pharmacy</th>
<th>District or Higher Hospitals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural</td>
<td>Female</td>
<td>4.7 ± 3.6</td>
<td>10.7 ± 4.3</td>
<td>0.5 ± 0.5</td>
<td>84.2 ± 5.4</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>0.0</td>
<td>22.9 ± 7.4</td>
<td>2.0 ± 2.0</td>
<td>75.1 ± 7.6</td>
</tr>
<tr>
<td>Urban</td>
<td>Female</td>
<td>2.2 ± 1.4</td>
<td>11.2 ± 3.4</td>
<td>9.9 ± 2.6</td>
<td>76.7 ± 4.1</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>1.0 ± 1.0</td>
<td>4.9 ± 2.2</td>
<td>8.5 ± 5.2</td>
<td>85.6 ± 5.5</td>
</tr>
<tr>
<td>Total</td>
<td>Female</td>
<td>2.7 ± 1.3</td>
<td>11.1 ± 2.8</td>
<td>8.1 ± 2.1</td>
<td>78.2 ± 3.5</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>0.7 ± 0.7</td>
<td>11.2 ± 3.1</td>
<td>6.2 ± 3.5</td>
<td>81.9 ± 4.4</td>
</tr>
</tbody>
</table>

Among available healthcare service options for treatment of the three mentioned metabolic disorders, most people preferred district or higher-level hospitals (79.3%, higher in urban than in rural areas) compared to commune health station (11.2%), private clinics or pharmacy (7.5%) and self-treatment (2.0%), in which the last three options were similar between urban and rural areas (Table 10). It reflected the existing condition of insufficient resources on demands for CVDRF management at the commune level, even though only 15% of people having these disorders were treated at all.

In summary, the general adult population in Vietnam are facing an alarming increase in the prevalence of CVDRFs. CVDRFs are often clustered within individuals, increase with age and result in high demands for management, while the capacity to handle such large numbers of at-risk people is not available in a resource constrained country like Vietnam.
Community-Based CVDRF Intervention

Tackle CVDRFs Separately or Comprehensively?

People with high risk of CVD in the general population can be screened by: (i) a single prominent proximal CVDRF linking directly to a major adverse CVD event (e.g. hypertension for stroke); or (ii) a holistic score which combines major CVDRFs to estimate the overall CVD risk in certain period of time (e.g. in lifetime, in 10 years or shorter) [73, 92-95]. Then the decision on how to manage and follow up on a particular person will depend on the magnitude of this single CVDRF or the overall CVD risk. The holistic approach is preferred as CVDRFs are usually clustered within individuals and interact with each other, so that moderate reductions in several risk factors will be more effective than major reductions in a single factor [96-102].

Using the CVDRF pattern in the general population of Vietnam in 2009, our extrapolation suggests that targeting a single CVDRF (such as hypertension) without considering other modifiable CVDRFs (such as unhealthy diet or smoking) is not an efficient approach for achieving a high health impact for the community. The high-risk approach using the individual Framingham general cardiovascular risk score [79] would benefit the entire population more than only approaching a group of hypertensives. Our results also confirmed that a combination of population-wide and high-risk approaches is necessary, with the first priority being tobacco use reduction and the second being salt reduction in food (Figure 12).

**Figure 12.** Estimation of potential benefits of intervention strategies for the population of Vietnam (extract from Figure 3, paper II)
Moreover, using a single CVDRF approach to prevent adverse CVD events is sometimes more expensive than using the overall risk approach, which enables more accurate targeting of high-risk groups in the population [95]. Under the single risk approach, a person having high overall CVD risk but mild to moderate elevation of multiple CVDRFs could be easily ignored while many people having low overall CVD risk but high elevation of a single factor could be treated even if the risk-benefit ratio is low and the treatment is costly [95]. The implementation of overall risk is more cost-effective as the threshold of high CVD risk is raised regardless of drug efficacy and treatment cost [98, 103-108], which has important policy implications for low-resource settings where resource constraints are a major barrier for prevention [95].

There are several risk scores to estimate overall CVD risks at different certain periods of time, mostly including some basic parameters such as age, sex, blood pressure level, smoking status, diabetes and lipid profiles. Some recent risk scores integrate novel risk factors such as C-reactive protein, haemoglobin A1c, social deprivation, family history of premature CHD and so on [79, 94]. Actually, physicians in daily practice have to face the difficult clinical challenge of decision making based on many seemingly discordant risk estimations, which always have some uncertainty especially when the risk score is applied to different target populations compared to the population from which the original score was derived. While still being imperfect and inappropriate for promoting complacency [94], overall CVD risk assessment in asymptomatic people is increasingly advocated [75, 109-113], in which the overall 10-year or lifetime CVD risk scores are recommended for exploring individual future risk, to identify who is benefiting from proven preventive measures, and to engage more patients at an earlier stage by highlighting the necessity of early and lifelong interventions on their CVDRF profiles [94, 114].

Among these algorithms, the effective risk scores, which does not require expensive blood tests, are preferred in limited resource settings [79, 115, 116]. Our calculations in paper I showed the concordance between the traditional Framingham general CVD risk score using lipid profiles and the simplified version using BMI instead of blood lipid tests. However, the validity and applicability of each suggested CVD risk score should be carefully modified or calibrated in any target population to avoid the over- [117, 118] or under-estimation of CVD risk by the original risk score [119-126] and should be the first priority where no validated risk score exists, for example in Vietnam.
Commune Hypertension-Centred Management Programme

Community-based CVD interventions are programmes that attempt to modify the prevalence of one or more CVDRFs, CVD mortality or both within a defined community [127]. Four distinct generations of community-based CVD intervention programmes have already demonstrated the effectiveness of population-based approaches to address specifically targeted communities or sub-populations but have also highlighted the importance of multisectoral partnerships within the health care system, the involvement of non-health sectors and orchestrated multilevel interventions (i.e. social or physical environments and relevant public policies) [128-131]. However, the modest impacts of community interventions on CVDRFs also reflect the challenges in selecting the most potent or cost-effective strategies, the most likely-to-respond population, the appropriate model for evaluation, and especially the contextual factors required for effective intervention delivery [132-136]. Key factors for succeeding in a community-based intervention include a good understanding of the targeted population, the deep engagement of all involved partners, an effective dose of interventions in supportive environments and a reliable monitoring system [131, 136-138].

**Table 11.** Effects of public health services in early or late-adopter community, modified from Pearson TA [137]

<table>
<thead>
<tr>
<th>Public health service</th>
<th>Early-adopter community</th>
<th>Late-adopter community</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surveillance</td>
<td>Sufficient to arouse community and improve knowledge</td>
<td>Insufficient to arouse community</td>
</tr>
<tr>
<td>Media/Education</td>
<td>Enough to creates a social norm, to activate behaviour changes</td>
<td>Insufficient to activate community</td>
</tr>
<tr>
<td>Community organization/partnerships</td>
<td>Community organizations for heart health often ready in place</td>
<td>Need to rearrange existing organizations for partnerships</td>
</tr>
<tr>
<td>Assuring health services</td>
<td>Services available; high demand for preventive services</td>
<td>Need to reorient toward prevention</td>
</tr>
<tr>
<td>Policy/environmental change</td>
<td>Community will initiate policy/ environmental change</td>
<td>Needed to create milieu for behaviour change</td>
</tr>
</tbody>
</table>

Among three dimensions of a community intervention comprising targeted CVDRFs, a community setting and public health services, the last component
is critical for optimizing and maintaining the effectiveness in a late-adopter community, which are the communities lagging behind in terms of receipt of the ideas or opportunities for example in rural areas (Table 11) [131, 137, 138].

In addition to the prominent roles of health education in community-based CVD interventions, the systematic involvement of the primary healthcare system can be the most effective approach in the long run, especially when the programme targets metabolic CVDRFs such as hypertension, diabetes or dyslipidaemia [131, 139, 140]. In Vietnam, while communicable diseases currently overload the primary health care system and the knowledge of local health care teams on CVDs or CVDRFs is inadequate, health service improvement is one crucial component of any community intervention so that the local primary healthcare system has enough capacity to carry out the essential public health services as well as provide chronic care for people requiring treatment [18, 42, 56].

Implementing a commune-level hypertension-centred management programme such as the model in Ba-Vi district was an initial step to strengthen the primary health care system so that local people could promptly receive the necessary cardiac care services on site. After successful implementation, each local commune health station would become an independent node and join in the national cardiac care network with steady support from reference cardiac centres (paper III). The three complementary targets in the model are: (i) entire commune for health promotion; (ii) hypertensive patients for monthly check-ups, drug delivery and lifestyle consultation; (iii) local health care system by for upgrading (Figure 13).

**Figure 13.** Process for implementing a hypertension management programme
Paper III summarized both top-down and bottom-up approaches on how to engage all involved sectors in the hypertension management programme, which is a new community-based intervention on CVDRFs implemented in rural low-resource settings where people were only familiar with traditional infectious diseases. The implementation also highlighted the importance of the close collaboration between local authorities, a supportive cardiac care network and national health authorities for sustaining the intervention activities and its national implications [131]. In the context of a pilot model in a small community, it is very difficult to include collaboration with industry or businesses to create supportive environments, but this policy may be very cost-effective in national-level interventions [131].

One main goal of the hypertension management programme was to improve the capacity for cardiac care, especially hypertension care, among a local team of health workers. Among CVDRFs, hypertension was chosen as a trigger for the programme because it was so prevalent in the local community; it directly linked to stroke that was the leading cause of CVD mortality and morbidity in the rural area; it was easy to implement and train due to simple and reproducible measurements using automatic devices; changes in BP can be self-witnessed to improve the adherence to the life-long multidrug treatment or individual behavioural changes.

Management capacity and knowledge of the local team on CVD and CVDRFs is also very important because local health workers are mainly responsible for chronic care management and the delivery of preventive services for local inhabitants [139]. Supported adequately, primary health workers could deliver lifestyle consultations to the patients; tailor the community intervention to specific individuals in local areas; consolidate the impacts of health promotion and deal promptly with incidental CVD events, thus becoming a feasible and highly cost-effective approach in low-resource settings [141]. The severity of hypertension and effectiveness of treatment were the main factors influencing the decision of local people to join or leave the management programme, which support the initial selection of hypertension and primary care itself as the targets for a community-based comprehensive CVD intervention (paper III).

**Perception Of Cardiovascular Diseases In Rural Areas**

The preliminary results from our qualitative study in Ba-Vi district showed how local people formed the concept of new non-communicable diseases emerging in the community, like hypertension and stroke from the existing norm like “wind” and the vivid examples of experienced cured infection. Interacting with the traditional beliefs, social norms and information
updated from professional healthcare workers, the knowledge of local people on CVD or CVDRFs grew from the Awareness to the Assessment and finally the Action stage (Figure 14). Local people often perceived any CVDRF as a dichotomous variable, ignored the continuum of the CVD prevention; linked the adverse outcomes unavoidably with ageing or fate [142-145]; became “unrealistic optimists” in comparison with some local bad examples [143]; and preferred their own emotion-related experiences to evidence-based ones in building up a new reflection (“seen and confirmed”) [146]. Moreover, local people failed to appreciate the effectiveness of lifestyle changes or lifelong treatment, refused to take responsibility themselves for the progression of CVDRFs, expected immediate healing therapy for chronic problems, kept a fatalistic view of any CVD outcomes and mistrusted local care services. All of these incorrect and fragmentary perceptions demonstrated the ambivalence [147] and the complexity involved in creating or adopting a new concept of disease [146].

**Figure 14.** Perception pathway for cardiovascular diseases in rural areas

Similar to a widely known infection like tuberculosis [148], the stigma of an ambiguous chronic disease, the fear of high medical expenses and the lack of local health facilities were key factors behind the delays in health seeking for CVD including diagnosis and initiation of appropriate treatment. Data from our qualitative decoding revealed potential gender-gaps on health seeking behaviour for CVD in the area, which was strongly influenced by gender and family structure. In Vietnam, there are two gender constructions: the Confucian overlaps with the Socialist model [149, 150]. Confucianism traditionally assigned to women the values of hard work, chastity and proper behaviour, and focused on female subordination (i.e. moral code of “Three Obediences”). The Socialist women’s emancipation facilitated women being involved widely in social-political life (i.e. “Three Criteria Women Campaign”) and blended in traditional ideas related to women’s roles in the family [150].
However, women are expected to work diligently to better their families and always put the family’s interest ahead of their own, while men are expected to be the ‘family pillar’ with higher social roles, respect and priority, even in the allocation of healthcare expenses among family members [148, 150]. Even when there was a commune-based hypertension management programme locally available, women still deviated from the programme, possibly explained by the traditional roles of women in the family that tended to disadvantage them and lead to neglect of chronic diseases until obvious symptoms occurred (paper III). The gender hierarchy embodied in tradition and culture seems to create barriers against women accessing quality preventive and curative measures and thus widens the gaps in gender equity for effective management of communicable [151] and non-communicable diseases [152-155].

**Community-Based Comprehensive Healthy Lifestyle Promotion**

The risk of having a CVD event later in life is influenced in a cumulative fashion by social and environmental health determinants together with behavioural and metabolic CVDRFs acting throughout the life course [8, 156-160]. The incidence and mortality of CVD increase and the quality of life decreases progressively with the number of CVDRFs [161-164]. Often co-occurring as clustered risk factors, lifestyle and cultural habits influence metabolic disorders more than genetic factors [165]. A composite measure of multiple behavioural CVDRFs can predict mortality, above and beyond the predictive value of any single behavioural CVDRF [166-169]. Behavioural risk factors accounted for 50-80% of contributors to chronic disease including CVD [170]. Lifestyle changes such as smoking cessation, healthy diet, and increasing physical activity show excellent cost effectiveness in lowering the CVD burden [171]. Compared to most proven clinical preventive measures, lifestyle intervention results in more than fivefold return even though being imperfect [172]. Prevention by lifestyle changes works better than drugs and lasts longer than percutaneous coronary interventions or surgery, but only if it is done early in life [170]. So, comprehensive healthy lifestyle promotion should be a centrepiece of any efforts to improve cardiac health [173].

The health promotion in our quasi-experimental intervention study applied recommended top-priority, population-wide, highly cost-effective and affordable interventions [32, 35, 51, 53, 174] including smoking cessation, reduction of alcohol consumption, encouragement towards healthier diets and increased physical activity. All these components encouraged local people to adopt a healthy lifestyle to prevent or delay the negative effects of CVDRFs at low cost [175]. Sharing the same messages, health promotion was
also combined with individual lifestyle consultations for hypertensives to improve patient adherence to chronic care management of hypertension. Contents for health promotion were also tailored for local demands and requests.

Our intervention study showed that community-based health promotion significantly decreased the prevalence of salty diets (6.4-7.4%), had no impact on prevalence of smoking, and had inconclusive impacts on the prevalence of heavy alcohol consumption (decreased in reference and intervention areas) and the prevalence of physical inactivity (increased in intervention commune) (Figure 15).

![Figure 15. Changes of prevalence of behavioural CVDRFs in the general population, after a 3-year health promotion intervention](image)

Our data also recognized the increase of physical inactivity with significant growth of waist circumference, indicative of a sedentary trend in the general population. The decrease of BP and alcohol consumption in the reference community, both of which were unexpected in relation to the CVDRF trends in the general population, might be explained by a Hawthorne effect from the baseline survey or diffusion effects due to population mobility (paper IV).
As in other studies [176, 177], the prevalence of smoking did not change with our health promotion campaigns despite being very common in the local male population in rural areas [66, 178, 179]. Deeply rooted and symbolized in social norms as a masculinity metaphor or a transformation indicator, smoking is accepted as a culturally internalized habit [180], which cannot be easily changed by gender-neutral CVD-oriented messages in opposition to other negative motivations such as the difficulty of struggling against dependency [180] or the fear of weight gain after smoking cessation [181]. Being a strong context-bound behavioural CVDRF, any changes in smoking can be influenced and maintained by supportive social-cultural environments such as tobacco tax and legislation to ban smoking in public areas. Lifestyle interventions theoretically require long-lasting social, political, and economic will to forge multi-level changes among individuals, communities, health systems, and health policy makers [182].

A comprehensive lifestyle intervention should include both primordial and primary prevention to avoid CVDRFs, control existing CVDRFs and defer CVD onset which can bring desired outcomes such as reductions in CVD incidence, mortality and morbidity, and improved quality of life [183]. Individual adherence to comprehensive healthy lifestyles is associated with lower long-term CVD risk [184-186]. However, due to some dilution biases such as social diffusion, population mobility, time lag and multifactorial natural progression of CVDRFs, the effects of any population comprehensive intervention are usually weaker and less certain in relation to mortality and morbidity outcomes, rather than on intermediate outcomes such as changes in intervened CVDRFs [187].

In our intervention study, changes in blood pressure and CVDRF patterns were chosen as the outcomes because they are closely linked to the contents of the interventions, sensitive to the marginal effects and can be self-witnessed to motivate local people to become more involved in CVD prevention activities. However, there are still a lot of unanswered questions on how to optimize the comprehensive health promotion at the individual or population level [169] such as (i) the ideal number of behavioural CVDRFs on which to intervene, (ii) whether intervene on several CVDRFs simultaneously or sequentially [188], and (iii) how to get positive synergistic effects across individuals and the population as a whole [189].

Besides the modest impacts on behavioural CVDRFs, health promotion activities in our study brought significant reductions of 3.0-3.3mmHg in SBP and 4.6-4.7mmHg in DBP after accounting of the effectiveness of the management programme (paper IV). Consequently, the commune-based integrated intervention model significantly improved the awareness,
treatment and control of hypertension in the intervention area (Figure 16 and 17).

Figure 16. Changes in blood pressure distribution after 3-year intervention
In summary, our results suggested a model of comprehensive community healthy lifestyle promotion combined with a commune-based programme on hypertension management was effective in improving CVDRFs and feasible for integration into existing primary health care facilities and then expansion to the national level. Both population-wide and high-risk individual approaches were simultaneously implemented at the commune level to optimize and deal with local demands of CVDRF management. Table 12 summarises the different characteristics of two main approaches.

In 2009, the Vietnamese Prime Minister approved a National Targeted Programme on Prevention and Management of Hypertension, which was proposed and submitted by VNHI. It was a remarkable milestone when the data and experience from our model were applied nationwide, strengthening the primary healthcare system towards better prevention and management of CVDRFs at commune level. In the future, this model can be used as a framework for commune-level interventions for more advanced CVD or other chronic diseases.
<table>
<thead>
<tr>
<th>Approach</th>
<th>Population (Public Health)</th>
<th>High-risk (Clinical)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target</td>
<td>Entire population</td>
<td>People with high CVD risk</td>
</tr>
<tr>
<td>Preventive focus</td>
<td>Primordial and primary</td>
<td>Primary and secondary</td>
</tr>
<tr>
<td>Overall aims</td>
<td>Reduce incidence or delay the onset of CVDRFs</td>
<td>Control existing CVDRFs and delay the onset of CVD</td>
</tr>
<tr>
<td>Specific measures</td>
<td>Healthy lifestyle: stop smoking, reduce alcohol consumption, encourage healthy diet and physical activity, reduce stress</td>
<td>- Stop smoking - Control hypertension, diabetes, dyslipidaemia - Maintain optimal weight, BMI, waist circumference</td>
</tr>
<tr>
<td>Benefits/ Costs</td>
<td>+++/+</td>
<td>+/+</td>
</tr>
<tr>
<td>Requirements</td>
<td>Aware health policy makers and involved intersectoral partnership</td>
<td>Qualified primary health care system supported by cardiac care network</td>
</tr>
<tr>
<td>Evaluation</td>
<td>Cardiac health population metric by repeated cross-sectional surveys</td>
<td>Changes in CVDRFs or in the overall CVD risk by periodical screening and follow-up activities</td>
</tr>
<tr>
<td>Resistance</td>
<td>- Vague outcomes - Politician inertia - Social health norm/belief</td>
<td>- Individual perception - Physician inertia - Budget constraint - Incapable or overload healthcare system</td>
</tr>
<tr>
<td>Priority strategy</td>
<td>Policy-level intervention esp. smoking &amp; salty diet</td>
<td>Individual management by multi-drug combination</td>
</tr>
<tr>
<td>Priority task</td>
<td>Gender-specific contents for behavioural change intervention in community</td>
<td>“cheap, simple, valid” score and threshold to identify almost high risk people</td>
</tr>
</tbody>
</table>
Methodological Considerations

Study Limitations

Cross-sectional surveys were the main approach in our study for collecting data on CVDRFs in the general population of Vietnam in different areas at different times. Using random sampling strategies with standardized STEPwise-based questionnaires and identical protocols, these surveys were able to capture the representative characteristics of the studied populations. During each survey, measured biological CVDRFs such as blood pressure or body size (weight, waist and hip circumference) at a single visit [190] sometimes failed to reflect the “real” values of these parameters, which can vary in their own natural circadian rhythms or depend seasonally on weather or harvest cycles, especially in rural areas. Behavioural CVDRFs and medical history of CVD or other chronic diseases are assessed by self-reported questionnaires, which can be easily misclassified by recall bias. However, these inherent data-driven biases of any surveys can be minimized with well-trained surveyors and strong quality control procedures by identical core teams from VNHI. Specific stratification (by sex or residential area), age standardization and multi-level analyses are complementary statistical procedures applied to manage the heteroskedasticity across the surveys at different times or areas. Due to time and budget constraints, some data was missed in some surveys (such as or dyslipidaemia or diabetes diagnosed by blood tests), resulting in increased uncertainty of our estimates or making it impossible to further explore CVDRF interactions. With acceptable and predictable limitations, cross-sectional surveys can be considered as feasible, flexible and appropriate tools for assessing CVDRFs in the general population. Repeated cross-sectional studies can be carried out periodically to monitor the prevalence of variables of interest over certain periods of time (as a pseudo-longitudinal study) and these results could be used in public health policy planning or the development of intervention strategies [191].

The quasi-experimental study design was applied in our study to evaluate the effectiveness on CVDRFs of the local hypertension management model and community health promotion campaigns. Initial cross-sectional surveys were used as a screening study to assess baseline CVDRF patterns as well as to recruit hypertensive patients for the local hypertension management programme. The inherent weakness of the lack of random allocation between intervention and reference groups make the quasi-experimental design able only to inform rather than to establish any cause-effect link, which can be confirmed in the true experimental studies. In low-resource settings like Ba-Vi area, a quasi-experimental design is most appropriate due to the logistics
for random assignment not being affordable, as well as the impossibility of avoiding “contamination” of the reference group (by effects from the screening survey itself, the awareness of CVD knowledge in local area being low and the demand being high) and the hypertension management programme being developed over time. However, this design is very valuable by providing information on whether some outcomes are changing while others are not as well as the magnitude of changes over time and which subgroups of the population could benefit from the programme.

The economic and social structure of Vietnam has changed dramatically from that of a poor to a lower-middle income country in the last decade, followed by rapid changes in the CVDRF pattern in the general population. This period of epidemiological transition could amplify changes of CVDRFs in the population so that the secular progression could be easier to identify through repeated cross-sectional surveys without a traditional longitudinal cohort study, which is more costly, requires more time or resources and is even unsuitable sometimes for areas with high proportion of missing data due to local migration. However, this amplification effect can also distort the real effects from community interventions and make the interpretation of these results more difficult especially when there are no reference groups.

The commune-based hypertension management programme integrated with comprehensive health promotion in our study showed effectiveness on CVDRFs based only on outcomes evaluated in the short-term. Due to budget constraints, the data on blood lipid profiles in the general population were missed, as well as hypertension being the only target linked to multi-drug combinations at the current stage. Sharing the same risk factors with other chronic diseases, besides CVD outcomes, components of comprehensive lifestyle promotion potentially influence other chronic diseases in the general population such as cancer or chronic lung diseases. Further studies are needed to evaluate the sustainability of reduced CVD outcomes as well as the potential impacts on other prominent chronic diseases in the community.

**Future Directions of the Study**

Major CVDRFs increased at similar rates between urban and rural areas while the gaps between CVD burdens and management capacity were bigger in rural areas. The decision to pilot, develop and expand the hypertension management model in rural communes targeted people living in rural areas, which constitute nearly 70% of the population in Vietnam [80], although the rapid urbanisation is occurring widely. People living in urban areas have easier and quicker access to public or private health care services while
people in rural areas depend much more on the local primary health care system. Modest impacts of the comprehensive lifestyle interventions in rural areas demonstrated the necessity to apply more intensively the qualitative approaches on these settings. Focusing health education at different perspectives based on gender, social, and cultural aspects is a promising strategy for engaging more social partners, ultimately changing the social norms of many behavioural CVDRFs or health seeking habits, and then motivating individual behavioural changes. Further studies are needed in urban areas where the hypertension management programme could be implemented in different settings such as workplaces, etc. with various properties and impacts [138]. Policy-level interventions are also other research focuses for the future.

The hypertension management programme at commune level combined with comprehensive health promotion in our study demonstrated feasibility for expansion over the country and the ability to integrate this model into the existing primary healthcare system. Besides the population intervention measures, which often have a low cost of implementation [175], the high-risk approach requires periodic screening tests, which would be more costly (for example blood tests to detect hypercholesterolaemia), and multi-drug combinations, which potentially put new financial and resource loads on the primary healthcare system, already overloaded with infectious diseases. Cost-effectiveness studies are needed in the future to evaluate the economic aspects of the programme, identify subgroups which can benefit most and the most appropriate intervention measure in the context of budget constraints.

**Reflection on Concept Evolution**

With my background as a consultant in intervention cardiology, firstly I joined in the epidemiological surveys on hypertension (NESH) in 2001 as a surveyor and then joined in other studies as member of the VNHI team for the population epidemiological and intervention research. On experiencing and adapting to strange research fields like statistics and public health, I have had to reappraise, add or sometimes integrate a lot of concepts, which have driven the directions of my studies as well as this thesis.

*From “disease” to “risk factor” concept*

Initially, for myself as well as other doctors in my team, hypertension is considered as a chronic disease - the original concept of “disease” from our antecedent doctors in medical school. We were taught the idea that people with hypertension, defined by some arbitrary cut-point, regardless of their
age, gender, or the presence of other CVDRFs, should be detected and controlled with multi antihypertensive drug therapy. Being a disease, we assumed, hypertension should be targeted for intervention and other risk factors such as obesity, smoking, excessive alcohol intake, physical inactivity, stress and high levels of dietary salt were considered as risk factors for hypertension. At that time, the concept of “risk factor” appeared not far from the cause-effect link and the concept of CVDRFs or “high CVD risk” was confusing, difficult to grasp and therefore easily ignored.

In my daily clinical practice, a lot of my patients presented with severe end-stage CVDs such as stroke or CHD but with only mildly elevated hypertension, while quite a number of others, especially young patients, had very high blood pressure without apparent signs or symptoms of CVDs. Many patients cannot have their BP controlled under 140/90 mmHg with many antihypertensive drug combinations although they may still benefit from some blood pressure reduction. Slowly, hypertension lost its role as a CVD outcome and became a convenient surrogate for following up treated patients. The actual demand shifted to the challenging assessment and management of future risk of sudden major adverse CVD events, which are becoming prominent in many booming towns around the country. Motivated by these trends and the overall CVD risk assessment embedded in international guidelines [73, 93, 98], we are adopting gradually, but increasingly widely, the concept of “high CVD risk” and accepting hypertension as a risk factor rather than a manifestation of CVD.

However, when the model of hypertension management was implemented in the primary healthcare system, the local healthcare worker team had to struggle with this conceptual shift. People tend to ignore a risk factor but fear a disease, even when both concepts refer to the same thing, like hypertension. In my proposal’s defence, I have been asked several times to differentiate between the “disease” and the “risk factor” concept for hypertension. For low-resource settings like ours, with low levels of knowledge and perception of hypertension, the “disease” concept of hypertension could be used to motivate the population to accept and adopt healthy lifestyles including the reduction of salt, which causes about one third of new cases of hypertension. At a later phase, when the management programme is running smoothly and people already recognize the importance of hypertension, the target will be all major CVDRF and CVD outcomes, and then hypertension can return to its original role as a “risk factor”.

In the National Targeted Programme of Prevention and Management of Hypertension, after launching quite a number of mass-media health
education campaigns on hypertension and healthy lifestyle, we step-by-step introduced the “risk factor” concept of hypertension and merged it with other CVDRFs. The data entry form for the hypertension management software or the paper sheets used in screening surveys was embedded with simple overall CVD risk assessment so that the health workers in the primary care system could be acquainted with and follow the “risk factor” concept.

**From “poly-pill” to “policy” intervention**

Analysing community-based data, I have recognized the huge burden of CVDRFs on the general population and the potential benefits of proven cost-effective interventions. Compared to the costly and time-consuming procedures I have done daily in order to gain some quality of life years for individuals, this has been at the expense of stressing that population interventions are much more likely to have a large health impact. Clearly both are required and a balance is needed.

Implementing the programme on hypertension management at the level of the commune health station, I have recognized the limitations of the existing primary health care system to manage CVD/CVDRFs. This management model targeted at hypertensives will be highly dependent on well-functioning primary healthcare system, which requires comprehensive approaches and coordinated health policy changes [56]. Moreover, the model challenges the current capacity of the outmoded healthcare systems, with the system soon becoming overloaded by emerging treatment demands, which require corresponding health policies in order to reasonably allocate financial resources (such as the application of insurance at primary heath system) or professional health worker resources (such as the development of a cardiac care network from primary to tertiary or regional hospitals).

In conducting some qualitative research and then evaluating the community intervention study, I have recognized the context-bound aspects of CVDRFs especially the behavioural ones. All elements of the agro-eco-socio-system have hidden but very high impacts on population health, not only through the population dietary intake [54] but also through complex interactions between economic cultural determinants from childhood or even earlier [8, 30]. The negative impacts of CVDs (or chronic diseases) on human and economic development of individuals, families or entire countries should be solved comprehensively and alongside other pressing national problems, which requires broad political commitment, leadership at high level and coordinated coherent strategies for action.
Following the commune management model, the National Targeted Programme of Prevention and Management of Hypertension indicated our advocacy approach to address CVD burden in the general population: bringing community-level evidence for health policy makers to determine the most appropriate health policies in order to mobilize all social resources to improve the health of the population.
Conclusion and Policy Implications

The general population of Vietnam is facing an epidemic of cardiovascular risk factors (CVDRFs) which are increasing rapidly, and clustered within individuals. While the management capacity for these CVDRFs is low especially in primary healthcare systems and in low-resource settings, these trends in CVDRFs at population level threaten a considerable projected CVD epidemic in a short time in the absence of rapid and widespread appropriate reactions.

Two approaches should be simultaneously applied to tackle this emerging problem, including a population-wide approach with community health promotion and a high CVD-risk individual approach with multi-medication. Policy-level interventions targeted at smoking and reduced salt diets should be the first priority for population interventions, while multi-drug strategies could be reasonable for high-risk individual interventions. Calibration or modification of an existing score for identifying high CVD-risk individuals in the general population and applying a gender perspective to behavioural change interventions are necessary tasks, which need to be done first in order to optimize and maintain the long-term results of CVD intervention.

Implementing the commune-based hypertension management programme in combination with community comprehensive health promotion campaigns is feasible in rural low-resource settings and effective in improving CVDRFs, especially blood pressure, in the general population. Hypertension is a likely key trigger-point for advancing the programme on managing other CVDRFs in future stages. This implementation is also a necessary step for strengthening the primary health care system towards a better capacity for chronic cardiac care management and enabling poor people to access the necessary services promptly and locally. Combined with surveillance activities via repeated cross-sectional surveys, this model can be used as an intervention framework for advanced CVD or other chronic diseases. The modest impact of health promotion on smoking and the sedentary trend in the community suggest that more supportive environments (e.g. health policy) or customized contents of health education (e.g. gender-specific) are needed to optimize the effectiveness and maintain the long-term impacts of population comprehensive healthy lifestyle promotion.

In developing countries like Vietnam, the prevention and management of CVDs or other chronic diseases cannot be separate from, but must cooperate and collaborate with, approaches for dealing with infectious diseases.
Besides the strengthening of the well-functioning health care system and the implementation of the robust evidence-based interventions, advancing the prevention of CVDs or chronic diseases requires coordinated political and stepwise health system actions, in which enlightened leadership at high levels and priority setting for using the most cost-effective interventions first are critical. Political oblivion or inertia rather than practical failure are likely to be the main barrier to addressing the CVDs or other chronic disease pandemics. Using a proximal surrogate like hypertension rather than other real fatal or non-fatal CVD endpoints, the model of community-based prevention and management of hypertension is reaching only a modest goal at its starting point. The National Targeted Programme on Prevention and Control of Hypertension in Vietnam, proposed initially by VNHI and approved subsequently by the Prime Minister in 2009, is needed not only to apply and expand nationwide the experience and estimation from the model of hypertension management at commune level but also to maximize resource mobilisation and fully awaken stakeholders and political leaders to the danger of the epidemic of CVDRFs. After extending the size, this programme will be broadened in its scope to target ultimate endpoints, such as a reduction in premature death due to CVDs or other non-communicable diseases.
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References


73. Chobanian AV, Bakris GL, Black HR, et al: Seventh report of the Joint National Committee on prevention, detection, evaluation, and

74. MOH: **Guidelines for management of hypertension.** Department of Therapeutics, Ministry of Health, Vietnam; 2010.


