University of Alberta

Correlates of Uncontrolled Hypertension Among Treated Canadian Hypertensives:
Results from the Canadian Heart Health Survey

by

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Dedication

This manuscript is dedicated to my mother and father, Susan and John Butler for all their love and support, and for teaching me the importance of perseverance and dedication. And to Sabrina who was the light by which I worked.

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Abstract

Hypertension (HTN) is an important cardiovascular risk factor that affects nearly a quarter of all Canadian and U.S. adults. Effective treatment of HTN is possible and significantly reduces risk of stroke and heart attack. Studies from around the world have shown that the majority of treated hypertensives do not achieve target blood pressure(BP). This study identified correlates of uncontrolled hypertension among treated hypertensives selected from the Canadian Heart Health Survey (CHHS) (n=1989). Data were derived from questionnaire and multiple blood pressure measurements. No information was collected on drug variables. Over 60% of treated hypertensives did not achieve target BP at the 140/90 mmHg level. Factors associated with inadequate response to therapy included: diabetes, age, first spoken language other than English or French, low education, part-time employment, Urban living, and heavy smoking. Conclusion: patients with high risk characteristics need to be identified early, and their antihypertensive regimens need close supervision.

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Chapter 1 - Hypertension

1.1 Introduction

Hypertension is one of the most common medical conditions in North America, affecting nearly a quarter of all Canadian and U.S. adults(1,2). Hypertension is a chronic condition of high blood pressure that is associated with an increased risk of cardiovascular morbidity and mortality(3). Hypertension is estimated to be involved in one quarter of all visits to General Practitioners and generates direct and indirect costs totaling 8 billion dollars a year in the U.S. alone(2). Hypertension is preventable and controllable and, when properly managed, can significantly reduce the incidence of cardiovascular morbidity and mortality(4-6). Awareness and control of hypertension have increased since the 1970s, but data suggest these improvements may have reached a plateau(1,3,7). Studies from Canada and around the world have shown that the majority of treated hypertensives do not actually reach target blood pressure levels(1,2,8-14).

The benefits of controlling hypertension are well established(4-6,15-17). A meta-analysis by Psaty et al. found that effective antihypertensive treatment can reduce the incidence of stroke (Relative Risk[RR] = 0.49), congestive heart failure (RR=0.58) and coronary artery disease (RR=0.72)(5). Over the past 30 years, major efforts have been made to reduce the public health burden of heart disease and stroke through control of risk factors such as hypertension. Data from the Canadian Heart Health Study has shown that despite these efforts 69% of treated hypertensives still have high blood pressure(2). Improving control of hypertension among treated hypertensives is an important area for improvement in the future of hypertension management in Canada.

1.2 History

The first prototype of the modern Sphygmomanometer appeared in 1896 and represented the first noninvasive tool with which to accurately measure blood pressure. In 1905 Korotkoff characterized the systolic and diastolic aspects of blood pressure measurement, thus establishing the basis for modern day blood pressure reading. The accumulation of blood pressure data by insurance companies during the early 1900s showed that people with high blood pressure died at an earlier age than people with low blood pressure. The insurance data revealed that the relationship between hypertension and mortality gradually increased up until blood pressures of 140/90 mm Hg, at which point the increase became much steeper(18). Collaborating data have since confirmed the relationship between mortality and hypertension(18,19).

1.3 Diagnosis

Hypertension is most often asymptomatic, therefore diagnosis most often depends on measured blood pressure rather than patient symptoms. Defining what level of blood pressure constitutes hypertension has been a matter of debate for years. There are a multitude of hypertension guidelines currently available, each with a similar, but not identical definition of hypertension. Organizations such as the Canadian hypertension working group(20), the World health organization/International Society of Hypertension(21) and the Joint National Committee (JNC) have each published high profile hypertension treatment guidelines. The treatment guidelines from the sixth report of the JNC take the most aggressive approach to treating hypertension, by recommending treatment for uncomplicated hypertension if the blood pressure exceeds 140/90 mmHg(3) (Table 1-1). The JNC VI definition of hypertension will be used throughout the remainder of this document.

Table 1-1 Hypertension classification for adults > 18yrs(3)

Status	Systolic Pressure (mm Hg)	Diastolic pressure (mm Hg)
Normal	<120	<80
High Normal	130-139	85-89
Hypertensive	>140	>90
Stage 1	140-159	90-99
Stage 2	160-179	100-109
Stage 3	>180	>110

Guidelines have been developed to ensure accurate and standardized measurement of blood pressure(3). Current JNC VI recommendations suggest the following steps be taken when measuring blood pressure: 1) blood pressure should be taken after the patient has been seated comfortably for at least 5 minutes, 2) patients should abstain from smoking and coffee for at least 30 minutes prior to measurement, 3) blood pressure should be measured using a mercury sphygmomanometer with the appropriate cuff size (bladder length should be 80% of upper arm circumference), 4) the average of two measurements, taken at least a 2 minutes apart, should be recorded as actual blood pressure, 5) elevated blood pressure measurements from at least 2 separate occasions (i.e., two visits to the doctor) are necessary for a diagnosis of hypertension. Another consideration when measuring blood pressure is a phenomenon known as 'whitecoat hypertension'. This refers to the potential for some normotensive patients to have transient, stress related, elevations in blood pressure while in a doctor's office(22). It is unclear whether the elevation of blood pressure seen in 'whitecoat hypertension' is associated with significant cardiovascular health outcomes(23).

1.4 Prevalence

North American studies(1,2) looking at the prevalence of hypertension indicate that 24% of adult Americans (43 million), and 22% of adult Canadians (4.1 million) are hypertensive(1,2). Evidence suggests that the prevalence of hypertension increases with age, is slightly higher in men than women (26% vs. 18%), and is higher for blacks than non-blacks (32.4% vs. 23%)(1,2).

1.5 Etiology and risk factors

Hypertension is categorized as primary or secondary depending on the underlying pathogenesis. Secondary hypertension denotes that a specific underlying disease process (i.e., renal vascular disease) is the cause of the elevated blood pressure. Primary, idiopathic, or essential hypertension is elevated blood pressure in the absence of any known disease process. Primary hypertension represents the majority of hypertension in adult populations and has been the main focus of hypertension prevention programs.

Risk factors for the development of primary hypertension have been well characterized in the literature. Table 1-2 provides a list of the risk factors that are associated with an increased risk of developing hypertension.

Table 1-2 Risk factors for developing essential hypertension(3,18,19,24)

Modifiable risk factors	Non-modifiable risk factors
• High dietary sodium	• Family history
• Inadequate dietary potassium	• Male sex
• Obesity	• Ethnicity (black>white)
• Sedentary lifestyle	
• Heavy alcohol intake	
• Glucose intolerance	
• Hypercholesterolemia	
• Increased uric acid levels	

1.6 Complications of uncontrolled hypertension

Untreated hypertension increases the risk of stroke, coronary artery disease, renal disease, cardiovascular mortality, and total mortality(3,7,16). The frequency of adverse cardiovascular events can be significantly reduced by lowering blood pressure with antihypertensive medications and lifestyle modifications(5-7,16). The benefits of treatment are only conveyed if patients adequately control their blood pressure. Improving blood pressure control is an important and effective means by which to reduce the public health burden of hypertension, cardiovascular, and renal disease.

Chapter 2 - Treatment of Hypertension

2.1 Treatment of hypertension

The primary goal of identifying and treating patients with high blood pressure is to reduce their risk of developing cardiovascular disease(3). Target blood pressure for treated hypertensives has been debated for many years, but organizations such as The Joint National Committee and the Hypertension detection and Follow-up Program Cooperative Group suggest initiating treatment for patients with blood pressures (BP) greater than or equal to 140/90 mmHg(3,25). During the period of data collection for the Canadian Heart Health Study (1986-1992) the recommendations for treatment initiation were not the same as they are today. For example, the 1984 Report of the Joint National Committee(26) used a blood pressure of 95/160 mmHg as the cutoff to initiate treatment. In 1988 the Canadian Hypertensive Society recommended treating patients whose blood pressure was above 160/100 mmHg(27). Clearly, the hypertension guidelines that are followed within a population will effect in whom treatment is initiated and in whom treatment is considered successful(28). This point should be kept in mind when interpreting the results from any study of the prevalence of hypertension control including the Canadian Heart Health Study.

Several large scale randomized trials have shown that reducing blood pressure to below 140/90 mmHg is instrumental in preventing stroke, congestive heart failure, coronary artery disease, renal impairment, and overall mortality(6,7,16). We now know that optimal level of blood pressure is ≤120/80 mmHg as even mild elevations in blood pressure above this level are associated with increased risk of cardiovascular disease(3). Management of hypertension can be achieved through the use of both pharmacologic and nonpharmacologic treatment regimens(29,30).

2.1.1 Nonpharmacologic therapy

Nonpharmacologic management of hypertension employs a variety of lifestyle modifications designed to reduce hypertension risk factors (Table 2-1). Lifestyle modifications are safe, inexpensive, and efficacious approaches to the prevention and management of hypertension(29-32). Between 1972 and 1990, the United States has seen a major reduction in the mortality rates for stroke (57% decrease) and coronary heart disease (50% decrease)(3). It is estimated that 50% of this decline could be attributed to lifestyle modifications such as increased exercise and healthier dietary habits(33,34). The remainder of the decline is attributed to improved pharmacologic treatment of hypertension as well as better tertiary care of cardiovascular events(33). The current JNC VI guidelines recommend using lifestyle modification for initial treatment of stage 1 hypertension, and as an adjuvant in any pharmacologic management of hypertension(3,30).

Lifestyle modification plays a key role in the prevention and treatment of hypertension(30). Even patients with blood pressure below 140/90 mmHg can reduce their cardiovascular risk by implementing blood pressure lowering lifestyle modifications(3,33). Implementing lifestyle modifications in the general population would reduce hypertension prevalence and would likely have a greater impact on cardiovascular morbidity and mortality than simply treating high risk individuals(3,19,30,35).

Lifestyle modifications that have been shown to be most effective in reducing the risk of hypertension are alcohol moderation, maintaining appropriate body weight, sodium restriction, increased exercise and adequate dietary potassium(3).

Table 2-1 Nonpharmacologic treatment of high blood pressure(3,29,30,32,35)

- Weight Reduction (Body Mass Index < 27 m/kg^2)
- Decreased Salt intake (<100 mmol/day)
- Increased Exercise (30 minutes walking/4 times a week)
- Adequate dietary potassium (90 mmol/day)
- Moderate alcohol intake (<30 ml ethanol/day)

Overweight patients face an increased risk of developing hypertension(29,30,32,35). There is a consistent and continuous relationship between all levels of increased body weight and level of hypertension(29,30). Reducing caloric intake in order to achieve weight reduction is associated with a decrease in blood pressure and may also improve the efficacy of drug therapy(3,24,29,35). Trials have indicated that weight loss of 4.5 kg can lower blood pressure in normotensive individuals at a rate of 1 mmHg/kg of weight lost(30). Weight loss in hypertensive people may also reduce the dose and number of drugs needed for treatment(3,30).

Excessive alcohol consumption is also associated with increased incidence of hypertension(30). Restriction of daily alcohol intake to no more than 30 ml of ethanol per day (i.e., 2 beers or 1 glass of wine or 1 shot of hard liquor) can reduce the incidence of hypertension and stroke(3). Like weight loss, alcohol moderation has been shown to improve the efficacy of antihypertensive treatment(30,35). Excessive alcohol consumption and obesity have independent and additive deleterious effect on hypertension(30). One study that combined moderation of alcohol with calorie restriction, showed reductions in systolic and diastolic blood pressures of 10.2 and 7.5 mmHg, respectively(30).

Increasing the level of exercise to 30 minutes of walking 4 times a week should be a part of all treatment regimens for hypertension(3). Increased levels of moderate exercise have been shown to reduce blood pressure, independent of any effect on body weight(30). When compared to active individuals, sedentary individuals have a 20-50% increased risk of developing hypertension(3).

High levels of dietary sodium are positively correlated with blood pressure(30). Restricting dietary sodium has been shown to significantly lower blood pressure(29,32). JNC VI guidelines recommend that daily salt intake not exceed

100 mmol(3). Reducing dietary sodium in patients receiving antihypertensive treatment may improve blood pressure control(36,37).

Adequate levels of dietary potassium have been shown to lower blood pressure and improve control in patients with hypertension(3). JNC VI recommends that dietary potassium intake be maintained at 90 mmol/day, preferably from sources such as fruits and vegetables. The use of potassium supplements is generally not needed unless a patient is using a diuretic that causes potassium wasting(3).

2.1.2 Pharmacologic therapy

Antihypertensive medications are the mainstay of antihypertensive treatment. There are now six classes of medications that are effective in reducing blood pressure. Studies have shown conclusively that antihypertensive medications are effective at lowering blood pressure and decreasing the incidence of cardiovascular endpoints known to be associated with hypertension(4-6,15-17). Selection of an antihypertensive drug regimen should be tailored to each specific patient as there is good evidence that antihypertensive drug classes have different levels of efficacy in different populations(38).

The 6th report of the Joint National Committee on Hypertension outlines current recommendations for the treatment of hypertension which reflect the interdependence of patient characteristics, hypertension severity and presence of other cardiovascular risk factors(3). For patients with Stage 1 (Table 1-1) hypertension pharmacotherapy should be initiated if lifestyle modifications have failed to control blood pressure within 3-6 months. Patients with Stage 2 or 3 hypertension should be treated with both pharmacologic and nonpharmacologic means. Once pharmacotherapy is initiated, it is important for primary care physicians to maintain adequate contact with patients to ensure compliance, monitor progress, and evaluate side effects.

Across North America increased emphasis on hypertension management has achieved significant improvement in hypertension detection and control rates(3,34). For example, over the past 20 years the proportion of hypertensive patients who are aware of their diagnosis has doubled, the prevalence of patients on treatment has doubled, and the number of controlled hypertensives has tripled(34,39). The percentage of hypertensive individuals who actually achieved target blood pressure while on treatment increased from 11%, in 1978, to 24%, in 1990(1). While these improvements are encouraging there is still much to be learned about factors associated with uncontrolled hypertension among treated hypertensives.

2.2 Response to therapy

Findings from a recent randomized control trial has shown that the majority of antihypertensive patients can achieve blood pressure control by using intensified therapy(40). In spite of this, blood pressure control among treated hypertensives remains poor(1,2,8-14,34,41,42). Studies from both North America and Europe have shown that less than half of patients receiving antihypertensive treatment have their blood pressure adequately controlled(1,2,8,13,43).

Setaro and Black have suggested that hypertensive patients should be considered refractory to therapy if their blood pressure remains above 140/90 despite an appropriate multi-drug regimen (> one drug), including a diuretic, with all medications at near maximal dosages(36). Using this or similar definitions, studies have shown that only 3% to 18% of patients are truly refractory to treatment(36). This suggests that the majority of inadequate responses to therapy are due to a failure in the implementation of the therapy, rather than a shortcoming of the therapy itself. For example, the Cardiomonitor study showed that 84% of treated hypertensives had no change in antihypertensive regimen when their target BP had not been achieved(44). Understanding the factors associated with inadequate response to therapy is critical in improving control of hypertension and preventing morbidity and mortality. There is a large body of research that has looked into reasons for inadequate response to therapy (Table 2-2). Physicians and patients need to be made aware of the potential pitfalls that can impair treatment in order to achieve good blood pressure control.

Table 2-2 Reasons for inadequate response to therapy(3,22,31,36,37,45)

1) Secondary hypertension to underlying medical problem

2) Pseudoresistance
   - "White coat" hypertension
   - Inappropriate cuff size
   - Severe Arteriosclerosis

3) Noncompliance

4) Drug related causes
   - Insufficient treatment regimen
   - Drug interactions

5) Volume overload
   - Excess salt intake
   - Nephrosclerosis

6) Patient characteristics
   - Smoking
   - Increasing Obesity
   - Sleep apnea
   - Insulin resistance
   - Ethanol intake >30ml/day
   - Chronic pain

Failure to achieve controlled blood pressure while on antihypertensive therapy can generally be attributed to one or more of the six factors listed in Table 2-2.

Before designating a patient as resistant to treatment it is important rule out pseudoresistance as a cause of a patient's continued hypertension. Pseudoresistance can arise from pseudohypertension, "white coat hypertension", and inappropriate cuff size.

Pseudohypertension is a condition in which the pathologic process of arteriosclerosis decreases the compliance of the patient's brachial artery therefore requiring a higher cuff pressure to occlude the artery(36). The higher cuff pressure is incorrectly attributed to hypertension when it is simply a complication of the arteriosclerosis(36,45). Another cause of apparent hypertension is the phenomenon of "white coat hypertension". "White coat hypertension" is a benign and transient rise in blood pressure that is caused by the 'stress' of being in a doctor's office. Lastly, the length of the blood pressure bladder must be greater than or equal to 80% of the patients arm circumference. Use of an inappropriately small bladder size can produce spuriously elevated blood pressure readings.

Patients with secondary hypertension have a specific underlying disorder that is the cause of their elevated blood pressure. It is important to rule out causes of secondary hypertension in any patient diagnosed with hypertension as their elevated blood pressure may be corrected when the underlying disease is corrected. Common causes of secondary hypertension are renal vascular disease, renal parenchymal disease, hyperthyroidism, pheochromocytoma, primary hyperaldosteronism, Cushing's disease and sleep apnea. Investigations to rule out secondary causes of hypertension should be reconsidered for patients with persistently refractory hypertension. Patients with secondary hypertension are an important, but relatively small fraction of the hypertension population(45).

Inappropriate treatment regimens are commonly at fault in patients that do not respond adequately to antihypertensive therapy(36,41,45-48). Patient are more likely to achieve blood pressure control if they are on a greater number of drugs, if they have been on drugs for a longer number of days, and if their doctors are more 'aggressive' about drug treatment(41,46,47,49). Frequent follow up visits to evaluate progress, drug side effects, and encourage compliance effects are critical to ensuring that patients are receiving the appropriate drugs in the appropriate dosages.

The concurrent use of over the counter medications while on antihypertensive therapy can cause deleterious effects of blood pressure. Substances such as alcohol, caffeine, non-steroidal anti-inflammatory, and sympathomimetic medications can cause blood pressure to be refractory to treatment(37,50-52). These substances can be divided into compounds that directly raise blood pressure, compounds that impair the action of antihypertensive medications, and compounds that improve treatment efficacy. Table 2-3 shows a list of common agents that can interfere with antihypertensive treatment.

Table 2-3 Drugs that can antagonize antihypertensive therapy(3,37,45,52)

Substance	Raise Blood Pressure	Impair Treatment	Lower BP
Ethanol	✓	✓	-
Nicotine	✓	✓	-
Sodium chloride	✓	✓	-
NSAIDs*	✓	✓	-
Corticosteroids	✓	✓	-
Caffeine	✓	-	-
Sympathomimetic (e.g., decongestants)	✓	✓	
Oral contraceptives	✓	-	-
TCA**	✓	-	-
MAO inhibitors***	✓	-	-
Potassium	-	-	✓
Calcium	-	-	✓

* Nonsteroidal antiinflammatory agents
** Tricyclic antidepressants
*** Monamine oxidase inhibitor

Patient adherence to treatment regimens is an important therapeutic challenge(31,45). Noncompliance has been consistently associated with inadequate response to therapy(14,46,50,53,54). Patient and treatment factors associated with poor compliance are listed in Table 2-4. Compliance can be a problem when patients lack motivation, knowledge, or the resources with which to comply with the prescribed treatment(3,36). Maintenance of patient compliance is also difficult because there is no symptomatic relief with treatment, only potential drug side effects(31). Some suggestions for the improvement of patient compliance are listed in table 2-5.

Table 2-4 Characteristics associated with noncompliance(37,48,50,55)

- Youth
- Male sex
- Obesity
- Current Smoking
- Fewer doctor visits
- No primary care providers
- No coexisting disease
- Low socioeconomic status

Table 2-5 Improving patient compliance(3,19,31,36,56)

Techniques
• Design therapies to be simple and inexpensive
• Anticipate and minimize side effects
• Involve patient in setting goals for treatment
• Educate patient about hypertension and the benefits that treatment offers.
• Maintain frequent contact with patient so as to quickly address complaints and questions, as well as provide encouragement

Patient characteristics make up an important group of variables associated with inadequate response to therapy. A variety of such patient characteristics have been identified and are listed in Table 2.-6. Patient characteristics encompass such things as comorbid conditions, patient behavior, socioeconomic status, and demographic characteristics. It is not clear whether these variables are associated with specific biologic mechanisms that interfere with blood pressure control, or if they are proxy measures of behaviours (i.e., noncompliance) that make controlling blood pressure difficult. Data show that conditions such as obesity, glucose intolerance and insulin resistance actually impair the function of antihypertensive medications(24). Both obesity and insulin resistance are independently associated with increased number of agents and dosages needed to control blood pressure(15,24). Weight loss of even four kilograms in overweight hypertensives enhances the blood-pressure-lowering effect of concomitant antihypertensive drugs(57).

Table 2-6 Patient variables associated with refractory hypertension

(1,3,12,13,24,34,36,45,46,54,55,58)

- Male Sex
- Older Age
- High blood glucose
- High BMI ($\geq$ 27)
- Sedentary lifestyle
- Current smoking
- Excessive alcohol intake
- Employment as a laborer
- Chronic pain

- High perceived stress
- Long duration of hypertension
- Previous treatment for hypertension
- Higher initial blood pressure
- No regular source of care (no doctor visit within 6 months)
- Cost described as a barrier to purchasing medication
- Previous myocardial infarction
- Previous stroke
- High serum creatinine
- Sleep Apnea

In order to improve treatment, it is important to be aware of such variables irrespective of the mechanism by which they impair treatment. Knowledge of the factors that contribute to refractory hypertension will allow doctors to identify high risk patients early on in the treatment process and implement appropriate interventions to overcome any barriers to blood pressure control

It is the objective of this study to identify correlates of blood pressure control among participants treated for hypertension in the Canadian Heart Health Study. It is the goal of this study to improve our understanding of factors related to inadequate response to therapy and thereby improve blood pressure control which will ultimately reduce morbidity and mortality associated with hypertension.

Chapter 3 - Materials and Methods

3.1 Objective and hypothesis

The goal of this study was:

a) To identify correlates of uncontrolled blood pressure among treated hypertensives.

Hypothesis: Antihypertensive treatment was likely to fail in patients who have the following characteristics: male sex(13,59), obesity(13,47,60,61), hyperinsulinemia(55,61), low socioeconomic status(61,62), no regular source of care(34,53), current smokers(54,63), excessive salt consumption(63), and non-adherence with prescribed therapy(14,45,54,64).

Preliminary analysis of the Canadian Heart Health Survey (CHHS) has shown that over half of patients receiving antihypertensive treatment still had high blood pressure(2). By identifying factors that influence treatment response doctors will be better able to focus on patients who were at high risk of having inadequate response to therapy.

3.2 Study design

3.2.1 Background on the Canadian Heart Health Survey

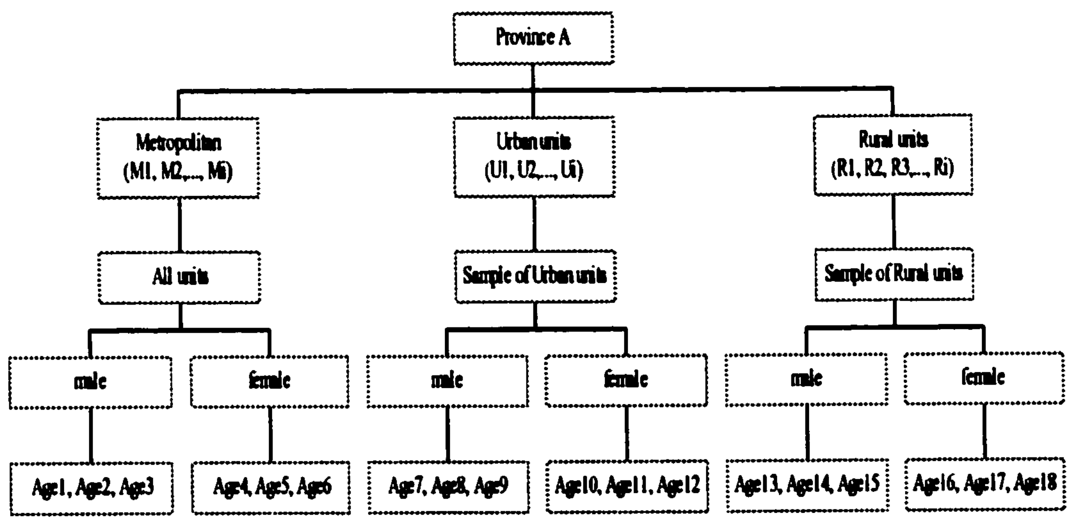
From 1986-1992 the departments of health from each of the 10 Canadian provinces conducted coordinated, population based, cross sectional surveys designed to estimate the prevalence of cardiovascular disease risk factors. The goal of these studies was to provide baseline data for future national and provincial cardiovascular disease (CVD) prevention programs. The data from each province were combined to create the CHHS.

The CHHS is a compilation of the ten provincial surveys, each of which followed a core protocol to ensure compatibility between surveys(65). The target population for each survey was Canadian adults, age 18-74 who were not living in an institution, military base, or native Indian reserve. The only exception to this was Manitoba, which included people living in institutions, reserves, or military bases.

3.2.2 Sampling

The study sample (N= 26,293) was selected from provincial health registries according to a stratified, two-stage probability sample design (Figure 3-1). Stage one sampling created primary sampling units. These sampling units were created as follows: each province was stratified into 3 geographic areas: metropolitan, urban and rural. These geographic areas were further subdivided into primary sampling units (i.e., municipalities, counties, census lots, census districts or health units, depending on the province). All metropolitan units were included as primary sampling units. A sample of urban and rural units was selected, with the probability of selection being proportional to the population of the unit. Thus all metropolitan units and a probability sample of urban and rural units formed the pool of primary sampling units. The primary sampling units were then stratified according to age and sex. The age groups for both male and female strata were: 18-34, 35-64, and 65-74.

Figure 3-1 Stage one sampling and strata formation for the CHHS



Stage two of the sampling design used provincial health insurance registries to select 2,200 individuals per province (Table 3-1). Because the prevalence of CVD risk factors increases with age, the younger age groups were over-sampled to provide adequate power for determining risk factor prevalence in these age groups.

Consistent with this, the three age strata were sampled with weighted probabilities designed to provide the following proportions in the sample population: 18-34=55%, 35-64=27%, and 64-74=18%.

Table 3-1 Age/sex strata targets for each province during stage two selection

Strata	Males	Females	Total
18-34	600	600	*1200 (55%)*
35-64	300	300	*600 (27%)*
65-74	200	200	*400 (18%)*
Totals	*1100 (50%)*	*1100 (50%)*	**2200 (100%)**

The actual number of participants from each province differed from the target numbers as a result of differential response rates from province to province(65).

3.2.3 Data collection

Data from the provincial surveys were collected from the participants in two steps. The first step was a home interview in which trained interviewers administered a questionnaire to the respondents and obtained two blood pressure measurements. The questionnaire explored such topics as: knowledge of CVD risk factors and their consequences, lifestyle variables and medical history of hypertension and hyperlipidemia. The second step of data collection was a clinic visit, which consisted of two more blood pressure readings, measurement of anthropometric variables, and collection of a fasting blood sample for plasma lipid analysis. In summary, all variables considered in the analysis were from the questionnaire except: cholesterol, body mass index, and waist to hip ratio. Of the total number of people invited to interview 78% completed the interview, 69% attended the clinic and 64% provided a fasting blood sample(65).

3.2.4 Weights

Weights were calculated for each study participant to reflect a) the differential selection probabilities, b) the proportion of the population that completed the questionnaire and clinic surveys, and c) the population structure within each province(65). Separate weights were calculated for clinic data and questionnaire data.

Statistics Canada calculated weights for the CHHD as follows(66):

Equation 3-1 $W^{*}_{phai} = \alpha_{pha} (N_{phai})/(m_{phair})$

Where:

- α_{pha} is the probability of being selected in stage 1 selection
- N_{phai} is the total number of people in the stratum p, h, a, i
- m_{phai} is the number of study participants from stratum p, h, a, i, who completed the home interview

Subscript legend:
p = provincial stratum
h = geographic area
a = primary sampling unit
i = age and sex stratum

Equation 3-2 $W^{1}_{phai} = (P_{pi}/P^{1}_{pi}) W^{*}_{phai}$

Where:

- P_{pi} is the Canadian population in stratum pi
- P^{1}_{pi} is the number of study participants in stratum pi

Equation 3-3 $W_{phai} = [\Sigma n / \Sigma W^1_{phai}] W^1_{phai}$

Where:

- n = the number of study participants
- ΣW^1_{phai} is the sum of weights across all participants

Equation 3-1 and 3-2 yield a study weight for each study participant that was standardized to the Canadian population. Application of equation 3-3 yields a final weight that was standardized to the study population. It follows then that the sum of W^1_{phai} equals the total Canadian population. The sum of W_{phai}, across all study participants, equals the total number of study participants (1,989).

3.3 Statistical analysis

3.3.1 Data analysis guidelines

Statistics Canada provides guidelines for the analysis of the CHHS, addressing issues such as: use of study weights, estimate quality, and design effects. The study weights were supplied by Statistics Canada and were calculated from Equations 3-1 and 3-2. Two study weights exist for the CHHS: one for variables derived from the household visit (questionnaire weight) and one for variables derived from the clinic visit (clinic weight). Clinic weights were calculated in a similar fashion to the questionnaire weights. To summarize, analysis of data obtained from the home interview and clinic visit should employ the questionnaire weights, and clinic weights respectively.

Guidelines to assess the quality of estimates were also included in the data use guidelines accompanying the CHHS. Low variability and satisfactory sample size were the criteria by which quality was assessed (Table 3-2).

Table 3-2 Standards of estimate quality

Estimate Quality	Guidelines
Acceptable	• >30 participants contributed to calculation of estimate • variability is <16.5%
Marginal	• >30 participants contributed to calculation of estimate • variability is 16.5%-33.3%
Unacceptable	• <30 participants contributed to calculation of estimate or • variability is >33.3%

Statistics Canada advises that design effects (DEFF) should be incorporated in the variance calculation for point estimates because of the complex nature of the CHHS sampling design. This recommendation was based on the fact that the variance estimates produced by statistics packages such as SPSS©(67) will likely underestimate the true sample variance. The reason for this underestimate of variance was because SPSS© assumed that the data were derived from a simple random sample and fails to account for the multistage, probability sampling design.

Design effects can be thought of as a correction factor that adjusts the variance produced by SPSS© to better approximate the 'true' variance. In this case 'true' variance was defined as the variance generated by the statistics program JACKVAR© – a statistics package designed to accommodate complex sampling designs as seen in the CHHS. JACKVAR© was not available for use in this study due to cost and logistical considerations. Statistics Canada calculated design effects for each variable by comparing variance estimates produced by JACKVAR© to those produced by software packages assuming a simple random sample (i.e. SPSS©) and then computing a correction factor to equate the two variances. The application of the design effects to the calculation of variance by SPSS© will provide an improved estimate of variance, although still less accurate than the variance calculated by JACKVAR©. The use of design effects is necessarily less accurate because they represent a single averaged value with which to adjust the variance of an entire variable whereas JACKVAR© is able to produce a variance for every category within a given variable.

A reference table of design effects was included with the CHHS indicating what magnitude of design effect was to be used when analyzing each independent variable (Table 3-3). Design effects ranged from 1.0 for variables such as age and sex, to 2.0 for diabetes, and was 1.5 for most other variables.

Table 3-3 Sample of design effects for independent variables

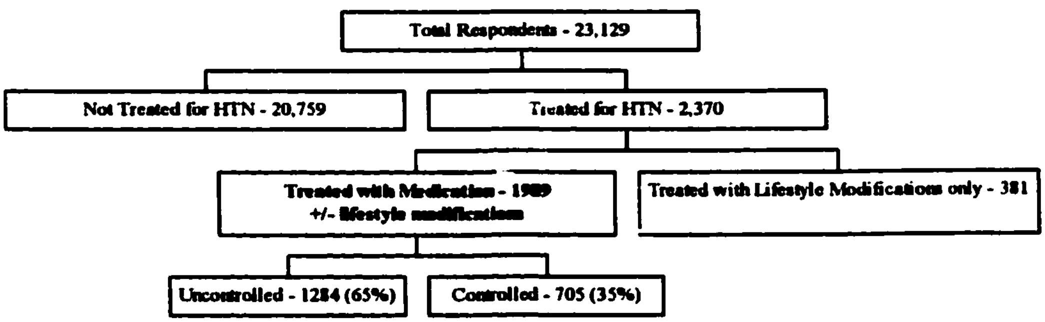
Independent Variable	Design effect required
Any age group	1.0
Sex	1.0
Body mass index	1.5
Years of education	1.5
Diabetes	2.0
Other home interview variables	1.5
Other Clinic visit variables	2.0

Design effects had to be utilized in the multivariate logistic regression analysis as well. This was problematic because different variables to be included in the modeling process required the use of different design effects. Therefore the approach taken in the multivariate analysis was to use an average design effect based on the different design effects associated with the variables included in the model building process.

3.3.2 Study population

The study population to be analyzed consisted of all participants of the Canadian Heart Health Survey who completed the questionnaire and were currently receiving antihypertensive therapy. Patients whose hypertension was being treated with only lifestyle modifications (i.e., no antihypertensive medications) were not included in this study because of the relatively long duration between implementation of treatment and control of blood pressure. By excluding hypertensive patients receiving only lifestyle modifications as treatment, it was hoped to create a better contrast between adequate and inadequate response to therapy. Therapy status was determined from questionnaire responses regarding pharmacologic regimens designed to reduce blood pressure. Participants receiving antihypertensive therapy were further stratified according to whether their blood pressure was controlled or not controlled (Figure 3-2). The final study population consisted of 1,989 individuals who had been prescribed antihypertensive medication. The majority of participants (1,284 (65%)) had not achieved blood pressure control at the 140/90 mmHg level.

Figure 3-2 Study sample selection



Blood pressure control was defined as a systolic pressure of $\leq$ 140 mmHg, *and* a diastolic blood pressure of $\leq$ 90 mmHg(3). In summary, the study population was comprised of all participants receiving antihypertensive therapy; the dependent variable was blood pressure control and the outcome of interest was uncontrolled blood pressure.

3.3.3 Bivariate analysis

Bivariate analysis was performed on variables that were clinically significant or that had been previously identified in the literature as being associated with uncontrolled hypertension (Table 3-4, Appendix A). The SPSS© statistical package was used to create tables evaluating the relationship between hypertension control and a variety of independent variables. Sampling weights and appropriate DEFF were utilized throughout the bivariate analysis. The weights used in the analysis were derived from equation 3-3 and represented study weights that were standardized to the age and sex strata of the Canadian population, as well as scaled down to the size of the study population. The appropriate design effect for each variable was ascertained from the design effect reference table included in the data use guidelines (Table 3-3).

The SPSS© *crosstabs* command was used to tabulate weighted two by two tables of dependent and independent variables. Odds ratios and 95% confidence intervals were produced by performing a weighted univariate logistic regression for each independent variable in the analysis. Statistical significance was defined as p-value < 0.05 or a 95% confidence interval that did not bound 1.0. Categorical variables that were suspected of following a trend were formally tested for trend using logistic regression and the Chi-square test for trend. Logistic regression was used to test for trend by modeling the categorical variable in its continuous form. If the slope of the resultant beta coefficient was non zero and statistically significant then the variable was said to exhibit trend.

Effect modification was evaluated through stratified analysis, Mantel Haenszel odds ratios and chi-square test for homogeneity.

Table 3-4 Independent variables for bivariate analysis

Questionnaire variables	Clinic variables
• Age	• Body mass index
• Sex	• Waist to hip ratio
• Urban/rural residence	• Serum cholesterol
• Education	
• Employment	
• Regularity of medical follow up	
• Language of childhood	
• Household income	
• Exercise	
• Diabetic status	
• Tobacco use	
• Alcohol consumption	

As mentioned in section 3.3.1, Statistics Canada indicated that design effects were needed to calculate corrected variances when analyzing the CHHS. Furthermore Statistics Canada included a reference table to indicate what magnitude of design effect should be used with each independent variable being analyzed. The design effect for a given variable was applied to the data set prior to analysis so that chi-square values and 95% confidence intervals would be calculated with the corrected variance. Design effects were applied to the data set using equation 3-4.

Equation 3-4 $W_{DEFF} = W_{phai} / DEFF$

Where:

- W_{DEFF} = study weight with design effect applied (effective sample size)
- DEFF = design effect (typical values included 1.25, 1.5, and 2.0)

By using equation 3-4 an effective sample size was calculated that was the quotient of the study weight divided by the design effect. Thus subsequent variance calculations for a particular independent variable would reflect the appropriate design effect in the SPSS© output (i.e., chi-square values and 95% confidence intervals). Several weight variables were created using equation 3-4 each reflecting a different magnitude of design effect. Weighting the data set with the appropriate study weight/design effect combination accommodated the different design effects required for each independent variable. For example when analyzing the relationship between the independent variable diabetic status and uncontrolled hypertension, the reference table indicated that a design effect of 2.0 was needed. So prior to tabulation and univariate logistic regression, the data set was weighted with a weight variable that was the quotient of the study weight divided by 2.0 (i.e., the necessary design effect). If the next variable analyzed required a DEFF other than 2.0 the data set would have to be re-weighted with the appropriate weight/DEFF combination before analyzing.

3.3.4 Logistic regression

Logistic regression is a parametric statistical model designed to describe the relationship between a dichotomous outcome variable and one or more independent variables(68). An unconditional logistic regression model was developed to identify variables associated with uncontrolled hypertension while controlling for any confounding variables. The logistic model was created using a manual, backward, step-wise model building technique. Variables to be used in the model building process included all variables with p-values greater than 0.25 in the bivariate analysis as well as variables whose clinical significance was deemed important. The contribution of each variable to the model was evaluated using the p-value associated with the Wald statistic as well as the likelihood ratio test. Significance of interaction terms was similarly assessed. When satisfied that the model contained all significant variables in the appropriate form, the overall fit of the model was assessed by the Hosmer-Lemeshow goodness of fit test. A more detailed discussion of the model building process can be found in the results section.

As in the bivariate analysis, weights and design effects were used in the development of the logistic model. An aggregate design effect based on the average design effect of all the variables to be included in the logistic model building process was used for logistic regression analysis. As with the bivariate analysis the design effect was applied to the data set prior to the analysis so that variance estimates were corrected. In the case of the logistic regression analysis the data set was weighted with a weight variable that was the quotient of the study weight divided by the aggregate design effect.

Appendix A

Summary of non-drug variables associated with Uncontrolled Hypertension

Research Group	Population	Variables associated with uncontrolled Hypertension
Chatellier G, et al.(13)	Hypertensives (N=5088)	1. Men 2. Increased BMI 3. Elevated Creatinine 4. Duration of HTN 5. Blood pressure level
MacDonald MB, et al.(69)	Urban hospital outpatient clinic (N=364)	1. High Calcium intake 2. Normal BMI 3. High perceived stress level
Stockwell DH, et al.(59)	New York Volunteers (n=1394)	1. Male sex 2. Fewer drugs in regimen
Barton SN, et al.(70)	Rural and urban Alabama residents (n=5237)	1. Urban residence
McClellan M, et al.(53)	Population based (n=4688)	1. Doctor visit for HTN > 6months
Degoulet P, et al.(55)	Hypertensive clinic Paris, France (n=1126)	1. Older Age 2. High blood glucose 3. History of stroke or Myocardial infarction 4. Evidence of Peripheral vascular disease

Wagner EH, et al.(62)	Rural North Carolina (n=539)	1. Lower age (females only) 2. Lower family income (females only)
Isaksson H, et al.(61)	Hypertension clinic (n=36)	1. Non insulin dependent diabetes mellitus 2. High body mass index 3. Manual Labour 4. Chronic pain 5. Mental distress
Macdonald MB, et al.(63)	Saskatchewan hypertensive clinic (n=60)	1. Smoking
Research Group	**Population**	**Variables associated with uncontrolled Hypertension**
Shea S, et al.(64)	Inner city, minority patients (n=93)	1. Low compliance* 2. No primary care physician 3. More than 6 months since BP checked 4. Problematic alcohol use 5. Illicit drug use 6. No insurance *measured by modified Morisky scale
McNagy SE, et al.(54)	Inner city African Americans (n=220)	1. Non compliance* 2. Current Smoking *measured by modified Morisky scale
Joshi PP, et al.(14)	Patients from urban Cardiology clinic in India (n=156)	1. Non Compliance* 2. Life Event Score** *measure by pill count **Psychosocial factors calculated from Holmes and Rahe questionnaire
Ahluwalia JS, et al.(34)	Indigent, minority inner city patients (n=133)	1. Not having a regular source of care 2. Doctor visit >6 months 3. Inability to afford medications

Chapter 4 - Bivariate results

4.1 Characteristics of the study population

The study population consisted of all participants in the Canadian Heart Health Survey who were currently receiving antihypertensive therapy. Subject identification and selection was outlined in Chapter 3. Demographic characteristics of the study population are outlined in Table 4-1.

The study population had more women than men (54% and 46%, t-test: $p < 0.01$) and an average age of 59 years (Table 4-1). Only 3% of participants were between the ages of 18 and 34. Most of the study population lived in an urban area (69%), and were predominantly from Ontario and Quebec (63%). Forty-five percent of participants completed high-school and 23% were employed full-time. Seventy-five percent of the study population listed English or French as the first language they learned to speak.

Sixty-four percent of participants did not have their blood pressure controlled on treatment. Hypertension control was ascertained from blood pressure measurements obtained during the home interview and clinic visit. Over eighty-five percent of the study population had four blood pressure readings. Average blood pressure for individuals with uncontrolled and controlled blood pressure was 156/89 mmHg and 127/80 mmHg, respectively (Table 4-2). Fourteen percent of participants reported having diabetes mellitus, 18% smoked regularly, and 47% of people exercised less than once per week.

Table 4-1 Weighted frequencies of sociodemographic characteristics

Variable	Categories	n(%)
TOTAL, n		1,989
Sex	Male	911 (46)
	Female	1079 (54)
Age (continuous) years ± S.D.		59 ± 11
Grouped age	18-53	483 (24)
	54-67	981 (49)
	68-74	524 (26)
Area of residence	Urban	1376 (73)
	Rural	519 (27)
Province	British Columbia	203 (10)
	Alberta	157 (8)
	Saskatchewan	64 (3)
	Manitoba	89 (5)
	Ontario	793 (40)
	Quebec	461 (23)
	New Brunswick	60 (3)
	Nova Scotia	94 (5)
	Prince Edward Island	13 (1)
	Newfoundland	54 (3)
Education	<Elementary	286 (14)
	Some secondary	807 (41)
	High school	695 (35)
	University degree	199 (10)
Employment	Full time	554 (28)
	Part time	145 (7)
	Unemployed	70 (4)
	Retired	669 (34)
	Homemaker	462 (23)
First language learned	English	1004 (53)
	French	472 (25)
	Other	418 (22)

Table 4-2 Weighted frequencies of cardiovascular risk variables

Variable	n (%)
Uncontrolled hypertension (BP > 140/90)	1230 (62)
Mean blood pressure:	
controlled (mmHg ± S.D.)	Systolic: 127 ± 9 mmHg Diastolic: 80 ± 6 mmHg
uncontrolled (mmHg ± S.D.)	Systolic: 156 ± 15 mmHg Diastolic: 89 ± 9 mmHg
BP checked within 6 months	1861 (94)
Dietary therapy for BP (in addition to BP Medication)	902 (45)
Diabetes mellitus	283 (15)
Regular smoker	362 (18)
Sedentary (exercise <1 /week)	940 (47)

4.2 Bivariate analysis

Statistical association between the dependent and independent variables was assessed using two by two tables generated by the SPSS©(67) statistical package. The dependent variable was blood pressure control on treatment - controlled hypertension (cHTN) vs. uncontrolled hypertension (uHTN) - and the outcome of interest was uncontrolled hypertension. Observations were weighted using the study weights supplied by Statistics Canada. Variable specific design effects were applied in concordance with the Data Use Guidelines accompanying the Heart Health Survey(66). Design effects were applied before the calculation of odds ratios and confidence intervals by dividing the weight variable by the square root of the design effect. This reduced the effective sample size by a factor equal to the design effect so that subsequent calculation of 95% confidence intervals (95% C.I.) reflected the increased variance (due to the reduced sample size).

Stratified analysis was used to assess **effect modification** for many variables in the bivariate analysis. Odds ratios for each stratum were compared to the Mantel Haenszel odds ratio using the chi-square test for homogeneity (degrees of freedom = number of strata - 1) . A significant chi-square test for homogeneity was interpreted to mean that the stratum specific odds ratios were significantly different from the Mantel Haenszel odds ratio and that effect modification was present. Any subsequent reference to the presence or absence of effect modification was based on the significance of the chi-square test for homogeneity, at the 0.05 level.

Confounding was evaluated in the bivariate analysis by comparing the crude odds ratio to the Mantel Haenszel odds ratio. Meaningful confounding was felt to be present if the difference in beta coefficients ($\ln OR_{crude} - \ln OR_{Mantel\text{-}Haenszel}$) was greater than 15% ($\Delta \ln(OR) > 15\%$). Any subsequent reference to the presence or absence of confounding was based on the above definition.

4.3 Analysis of cardiovascular variables

An important area in current cardiovascular research is risk stratification. Understanding the relationships between cardiovascular risk factors is important in determining prognosis and directing therapy. The relationship between cardiovascular risk factors and hypertension control are evaluated below.

4.3.1 Diabetes Mellitus

Diabetic status was based on respondents' answer to the question "Have you ever been told you have diabetes?". Ninety five percent of the study population had information regarding diabetic status. The recommended design effect for the diabetes variable was 2.

Uncontrolled hypertension was three times more common among diabetics as compared to non-diabetics (Table 4-3). Stratification by sex revealed that both male and female diabetics had a higher likelihood of having uncontrolled hypertension than their non-diabetic counterparts. The odds ratios (O.R.) for male and female diabetics were 3.79 (95% C.I. = 1.82-7.88) and 2.54 (95% C.I. = 1.45-4.46), respectively. There was no confounding or effect modification by sex.

The average age of diabetics was 61 years compared to non-diabetics who averaged 59 years (t-test: $p < 0.01$). There was no mean age difference between controlled and uncontrolled diabetics (t-test: $p = 0.33$). When stratified by categorical age, all age strata showed a statistically significant relationship between diabetes and uncontrolled hypertension (Table 4-3). There was no evidence of effect modification or confounding by categorical age.

Table 4-3 Diabetes and uncontrolled hypertension

	Diabetes	Unweighted N	Unweighted uHTN %	Weighted N	Weighted uHTN %	Odds ratio	95% C.I.
All Subjects							
	No	1494	64	1612	59	1	
	Yes	291	73	283	81	**2.99**	1.92-4.67
OR_{MH} (sex strata)	No					1	
	Yes					**2.98**	1.91-4.64
$X^2_{Homogeneity}$ (sex strata)						$X^2 = 0.24$	$p > 0.10$ (df=1)
Male							
	No	625	69	760	58	1	
	Yes	122	75	114	83	**3.79**	1.82-7.88
Female							
	No	869	61	852	60	1	
	Yes	169	70	169	79	**2.54**	1.45-4.46
OR_{MH} (age strata)	No					1	
	Yes					**2.85**	1.81-4.46
$X^2_{Homogeneity}$ (age strata)						$X^2 = 2.32$	$p > 0.10$ (df=1)
Age 18-53							
	No	291	49	415	41	1	
	Yes	28	54	47	79	**5.34**	1.91-14.89
Age 54-67							
	No	602	65	775	64	1	
	Yes	135	67	158	79	**2.18**	1.22-3.90
Age 68-74							
	No	601	70	421	68	1	
	Yes	128	82	77	87	**2.99**	1.14-7.87

Variables associated with diabetes, such as time since diagnosis and method of blood sugar control, were also considered in the analysis. The number of years participants had diabetes was obtained by subtracting age at diabetes diagnosis from current age. There was no statistically significant relationship between length of time since diagnosis and uncontrolled hypertension (O.R = 0.99, 95% C.I. = 0.96-1.03). The mean age at which diabetes was diagnosed was the same for uncontrolled and controlled diabetics (t-test: p = 0.90)

Blood pressure control was not statistically different between diabetics who used insulin and those who controlled their diabetes with diet or pills (O.R. = 0.89, 95% C.I. = 0.34 - 2.42).

Sociodemographic variables such as area of habitation, education, income adequacy and employment did not confound the relationship between diabetes and hypertension control. There was no effect modification after stratification by area of habitation. Effect modification could not be assessed for income, education and employment because cell size was unacceptably small according to Statistics Canada's data use guidelines.

In summary, participants with diabetes were three times more likely to have uncontrolled hypertension than those without diabetes. This was true for men and women and across all age strata. Other variables associated with diabetes such as insulin use and age at diagnosis were not associated with an increased likelihood of uncontrolled hypertension. Difference in sociodemographic characteristics could not account for any of the observed effect between diabetes and hypertension control.

4.3.2 Age

Information regarding age of study participants was ascertained during the initial selection process (through the use of provincial health insurance records) and verified during the home interview. All respondents had information regarding their age. The age variable did not require a design effect.

The CHHS contains both continuous and categorical age variables. The continuous age variable was not used in analysis because evaluating the relationship between uncontrolled hypertension per unit increase in age was not felt to be clinically useful. The categorical age variable included in the CHHS was based on the three age categories used in the initial sampling design: 18-34, 35-64, and 64-74 years. These age groups were chosen to evaluate the prevalence of cardiovascular risk factors, but given the small number of hypertension cases in the youngest age group, they were inappropriate for evaluating factors associated with hypertension control. As an example, the 18-34 age group contained less than three percent of people receiving treatment for hypertension (i.e., the study population). The continuous age variable was used to create a new variable based on age quartiles. Plot of the log odds ratio for each quartile against the midpoint of the quartile displayed a pattern that favored combining the two middle quartiles. This yielded three age categories: 18-53, 54-67, and 68-74 with case distributions of approximately 25%, 50%, 25%, respectively. In summary, a new categorical age variable with age groups 18-53, 54-67, and 68-74 was used in the analysis because it had better distribution of cases than the original categorical age variable.

Participants with uncontrolled hypertension were older than participants with controlled blood pressure with mean ages of 61 versus 57 years (t-test: $p < 0.01$). Crude odds ratios for the independent variable age showed that both the middle and oldest age groups were more likely to have uncontrolled hypertension than the youngest age group (Table 4-4). Chi-square test for trend and univariate logistic regression showed that hypertension control decreased as the age category increased in a linear fashion (t-test: $p < 0.01$).

Younger males and females had lower amounts of uncontrolled hypertension than their older counterparts. Sex exhibited effect modification in the comparison of middle to youngest age groups suggesting that the magnitude of association between age and uncontrolled hypertension was larger for middle aged men than middle aged women (Table 4-4). Sex did not confound any of the age categories ($\Delta \ln(OR) < 1\%$)

In summary, uncontrolled hypertension was more common in older individuals, and in particular middle aged men.

Table 4-4 Age and uncontolled hypertension

	Grouped age	Unweighted N	uHTN %	Weighted N	uHTN %	Odds ratio	95% C.I.
All Subjects							
All	18-53	372	48	483	45	1	
	54-67	827	64	981	65	2.36	1.89-2.95
	68-74	790	72	524	71	3.07	2.37-3.99
OR_{MH} (sex strata)	18-53					1	
	54-67					2.37	1.90-2.96
	68-74					2.89	2.14-3.94
$X^2_{Homogeneity}$ (sex strata)				54-67 vs 18-53		$X^2 = 6.31$	$p < 0.05$
				68-74 vs18-53		$X^2 = 2.89$	$p > 0.05$ (df=1)
Male							
	18-53	173	58	272	42	1	
	54-67	342	69	447	70	3.18	2.32-4.35
	68-74	310	74	192	66	2.64	1.80-3.87
Female							
	18-53	199	40	213	47	1	
	54-67	485	61	534	62	1.79	1.30-2.47
	68-74	688	72	333	75	3.20	2.22-4.60

4.3.3 Sex

Sex was recorded for all respondents. The sex variable did not require a design effect according to Statistics Canada recommendations.

Hypertension control was not different between men and women (O.R. = 1.07, 95% C.I. = 0.90 – 1.30).

On average, women were older than men (61years versus 58 years, t-test: $p < 0.01$) and men and women with uncontrolled hypertension were older than those who were controlled (t-test: $p < 0.01$, $p < 0.007$). Grouped age modified the relationship between sex and uncontrolled hypertension. In fact, it was a conditional effect modifier because in the middle age group women were less likely to have uncontrolled hypertension (O.R = 0.69, 95% C.I. = 0.53-0.90), but in the oldest age group they were more likely to have uncontrolled hypertension (Table 4-5).

The Mantel-Haenszel odds ratio across the three age strata was 0.97 (95% C.I. 0.80-1.12) compared to the crude odds ratio of 1.08 (95% C.I. = 0.90 – 1.30). The difference between the log odds of the Mantel-Haenszel odds ratio and the log odds of the crude odds ratio was 143% which would suggest that age confounds the relationship between sex and uncontrolled hypertension.

In summary, hypertension control was the same for men and women, although differences between men and women were seen in the middle and oldest age categories (i.e., confounding by categorical age). The best way to summarize the effect of categorical age on the relationship between sex and uncontrolled hypertension was through the age stratified odds ratios.

Table 4-5 Sex and uncontrolled hypertension

		Unweighted		Weighted			
	Sex	N	uHTN %	N	uHTN %	Odds ratio	95% C.I.
All Subjects							
	Male	825	69	911	61		
	Female	1164	62	1079	63	1.08	0.90 – 1.30
OR_{MH}	Male					1	
(age strata)	Female					0.97	0.80-1.17
$X^2_{Homogeneity}$							
(age strata)						$X^2 = 13.0$	P < 0.01 (df=2)
Age 18-53							
	Male	173	58	272	42	1	
	Female	199	40	213	47	1.23	0.86-1.77
Age 54-67							
	Male	342	69	447	70	1	
	Female	485	61	534	62	0.69	0.53-0.90
Age 68-74							
	Male	310	74	192	66	1	
	Female	480	72	333	74	1.49	1.01-2.20

4.3.4 Smoking

Information regarding smoking behaviour was gathered during the home interview by posing the question "are you a regular smoker?". All of the respondents had information regarding their smoking status. The recommended design effect for smoking variables was 1.25.

Uncontrolled hypertension was less common in participants who were regular smokers compared to non smokers, although this was not statistically significant (O.R.= 0.79, 95% C.I. = 0.61-1.02) (Table 4-6).

Stratification by sex revealed that uncontrolled hypertension was less common among male smokers with an odds ratio of 0.66 (95% C.I. = 0.43-0.87). Females did not show a statistically significant relationship between regular smoking and uncontrolled hypertension. Homogeneity testing was significant suggesting that sex was an effect modifier of the relationship between smoking and hypertension control (Table 4-6). There was no evidence of confounding.

There was no statistically significant association between smoking and hypertension after controlling for categorical age.

Stratification by area of habitation showed that, in rural areas, regular smoking was associated with an increased proportion of hypertension (O.R. 2.22, 95% C.I. =

1.36-3.74). The association was reversed in urban areas, where regular smoking was associated with a lower proportion of uncontrolled hypertension with an odds ratio of 0.52 (95% C.I. = 0.38-0.72). Rural regular smokers smoked more cigarettes per day than urban regular smokers with mean values of 23 cigs/day and 19 cigarettes per day (t-test: $p < 0.01$). Homogeneity testing showed that the rural and urban odds ratios were not statistically different from the Mantel Haenszel odds ratio of 0.81 ($X^2_{Homogeneity} = 2.88$, $p > 0.05$). There was no evidence of confounding by area of habitation.

Table 4-6 Regular smoking and uncontrolled hypertension

		Unweighted		Weighted			
	Smoker	N	uHTN %	N	uHTN %	Odds ratio	95% C.I.
All							
	No	603	64	1627	63	1	
	Yes	304	66	362	57	0.79	0.61-1.02
OR_{MH} for (sex strata)	No					1	
	Yes					0.81	0.62-1.06
$X^2_{Homogeneity}$ (sex strata)						$X^2 = 4.5$	$p < 0.05$ (df=1)
Male							
	No	691	69	705	64	1	
	Yes	134	69	205	52	0.61	0.43-0.87
Female							
	No	994	61	923	62	1	
	Yes	170	65	157	64	1.1	0.74-1.63

Study participants were also categorized according to the self reported number of cigarettes that they smoked each day. People with uncontrolled hypertension smoked more cigarettes per day than those with controlled hypertension with mean values of 3.99 and 3.33 cigarettes per day, respectively (t-test: $p < 0.01$). People who smoked 1-10 cigarettes per day had better hypertension control (O.R. = 0.29, 95% C.I. = 0.17-0.50) than people who did not smoke. Conversely, uncontrolled hypertension was three times more common among people who smoked 25 or more cigarettes per day compared to non-smokers (Table 4-7). A statistically significant trend in odds ratios from protective towards increased risk was seen as the number of cigarettes smoked increased, although smoking 11-25 cigarettes was not significant (X^2_{Trend}: $p < 0.05$)

Sex was a dramatic effect modifier ($X^2_{Homogeneity} = 19.56$, $p < .001$), such that men who smoked 1-10 cigarettes per day had markedly lower levels of uncontrolled hypertension than non-smokers (O.R. = 0.06, 95% C.I. = 0.02 - 0.18). There was no difference between women who smoked 1-10 cigarettes per day and their non-smoking counterparts (O.R. = 1.05, 95% C.I. = 0.50 - 2.21). Men and women who smoked $\geq$ 25 cigarettes per day had a much higher proportion of uncontrolled hypertension than non-smokers. In fact, 100% of women who smoked $\geq$ 25 cigarettes a day had uncontrolled hypertension which produced a zero cell and precluded the calculation of a meaningful odds ratio (Table 4-7).

Further stratified analysis of categories of cigarette use was not possible because of unacceptably small numbers of participants among the strata.

Table 4-7 Cigarettes per day and uncontrolled hypertension

	Cig/day	Unweighted N	Unweighted uHTN %	Weighted N	Weighted uHTN %	Odds ratio	95% C.I.
All							
	Not reg	1666	64	1607	63	1	
	1-10	72	68	92	33	**0.29**	0.17-0.50
	11-25	194	62	187	57	0.80	0.55-1.16
	>25	37	84	82	84	**3.09**	1.49-6.43
OR_{MH} (sex strata)	Not reg.					1	
	1-10					0.29	0.18-0.48
	11-25					0.80	0.57-1.13
	>25					-**	
$X^2_{Homogeneity}$ (sex strata)				1-10 vs. not reg		$X^2 = 19.6$	$p < 0.001$
				11-25 vs. not reg		$X^2 = 0.95$	$p > 0.10$ (df=1)
Male							
	Not reg	683	69	702	63	1	
	1-10	26	69	53	9	**0.06**	0.02-0.18
	11-25	83	65	89	56	0.74	0.47-1.15
	>25	24	80	64	80	-*	1.21-4.27
Female							
	Not reg	983	61	905	62	1	
	1-10	46	67	39	64	1.05	0.54-2.04
	11-25	111	60	99	59	0.85	0.56-1.30
	>25	13	92	18	100	-*	

* Statistics Canada advises that estimates based on counts of less than 30 were of unacceptable quality
** Table contained zero cells

In summary, people with uncontrolled hypertension smoked more cigarettes per day than those with controlled hypertension:. Despite this, uncontrolled hypertension was less common among regular smokers, although this was only statistically significant for men. The number of cigarettes smoked per day was perhaps more important than regular smoking status as smoking 1-10 cigarettes per day was associated with a three fold improvement in hypertension control whereas smoking >25 cigarettes per day was associated with three times higher proportion of uncontrolled hypertension. The improved hypertension control among people who smoked 1-10 cigarettes per day was only statistically significant for men. Smokers from rural areas had twice as much uncontrolled hypertension as rural non-smokers. Urban smokers displayed the opposite effect in that they had a two times lower prevalence of uncontrolled hypertension than urban non-smokers. The difference between rural and urban smokers might be related to the fact that rural smokers smoked more cigarettes per day than urban smokers.

4.3.5 Sedentary lifestyle

Participants in the Heart Health Survey were categorized with respect to exercise status using questionnaire data on frequency of exercise activities. All of the study population has information regarding their exercise status. People with an exercise frequency of less than one time per week for the last 4 consecutive weeks were considered sedentary. The recommended design effect for exercise variables was 1.5.

Hypertension control was not different between sedentary and non-sedentary participants (O.R = 1.06, 95% C.I = 0.85-1.32) (Table 4-8).

Uncontrolled hypertension was more common in sedentary men than non-sedentary men (O.R. 1.41, 95% C.I. 1.01-1.95). Sedentary women were more likely to have controlled hypertension although this was not statistically significant (O.R. = 0.84, 95% C.I. = 0.62-1.13). Sex was an effect modifier, but not a confounder.

Stratification by categorical age did not show any statistically significant association between sedentary lifestyle and hypertension control.

Table 4-8 Exercise status and uncontrolled hypertension

		Unweighted		Weighted			
	Sedentary	N	uHTN %	N	uHTN %	Odds ratio	95% C.I.
All							
	No	1083	65	860	61	1	
	Yes	906	64	770	63	1.06	0.85-1.32
OR_{MH}	No					1	
(sex strata)	Yes					1.06	0.87-1.36
$X^2_{Homogeneity}$ (sex strata)						$X^2 = 5.3$	$p < 0.05$ (df=1)
Male							
	No	475	71	378	57	1	
	Yes	350	66	368	65	1.41	1.01-1.95
Female							
	No	608	60	483	65	1	
	Yes	556	63	402	60	0.84	0.62-1.13

4.3.6 Regular medical follow up

Time since last measured blood pressure was assumed to be indicative of regularity of follow up. Participants were categorized as to whether or not their blood pressure had been checked within the last 6 months. All study participants had a value for this variable. The recommended design effect for this variable was 1.5.

Uncontrolled hypertension was actually more common in people who had their blood pressure checked within 6 months (O.R. = 0.75), although this was not statistically significant (95% C.I. = 0.49 - 1.19). Participants who had not had their blood pressure checked within six months had a lower average systolic blood pressure (t-test: $p < 0.014$), lower average diastolic blood pressure (t-test: $p = 0.60$), less diabetes (t-test: $p = 0.66$), and a greater number of university graduates (t-test: $p < 0.009$).

Sex modified the relationship between follow up and hypertension control ($X^2_{Homogeneity} = 4.5$, $p < 0.05$). Hypertension control was better in men who had not had their blood pressure checked within 6 months (O.R. = 0.49, 95% C.I. = 0.28 - 0.92). Conversely, women who had their blood pressure checked within 6 months were more likely to have uncontrolled hypertension (O.R. = 1.36) but this difference was not statistically significant (95% C.I. = 0.66 - 2.80).

Stratification by categorical age did not show a meaningful association between follow up and hypertension control.

4.3.7 Alcohol usage

Alcohol use among study participants was derived from questions asked in the home interview. While 95% of respondents had information regarding current drinking status, only 60% of respondents had information regarding daily frequency of alcohol use. Unfortunately, not all of the provincial questionnaires collected information on daily alcohol use (weekly or monthly intake was collected instead) accounting for the relatively low response rate of 60%. Respondents who had information regarding daily alcohol usage had the same age and sex distribution as the rest of the study population, but were all from Manitoba, PEI, NB, and NFLD. The daily frequency of alcohol use used to create a categorical variable with the following four categories: non-alcohol users, one drink a day, two drinks a day and three or more drinks per day.

Crude analysis of categorical daily alcohol use found no statistically significant relationship between daily alcohol use and hypertension control (Table 4-9). Stratification by sex and categorical age yielded no categories that showed a statistically significant relationship between daily alcohol consumption and hypertension control.

Table 4-9 Daily alcohol use and uncontrolled hypertension

		Unweighted		Weighted			
	Alcohol use	N	uHTN %	N	uHTN %	Odds ratio	95% C.I.
All							
	No alcohol	586	69	564	62	1	
	1 drink/day	285	63	54	61	0.95	0.47-1.91
	2 drinks/day	158	60	43	59	0.85	0.39-1.86
	≥3 drinks/day	166	68	49	63	1.09	0.52-2.30

Alcohol usage was also characterized based on questionnaire responses to the following two questions: "Ever had an alcoholic drink?" and "Have you had a drink in the past 12 months?". Based on their responses to these two questions they were categorized into never, former, and current alcohol users. Participants who answered no to the first question (185 respondents) were categorized as having never used alcohol. Participants who answered yes to the first question and no to second question were categorized as former alcohol users. Lastly, participants who answered yes to both questions were categorized as current users of alcohol. Ninety-five percent of subjects had information regarding alcohol usage (question was excluded in the Nova Scotia portion of the Heart Health Survey). The recommended design effect was 1.5.

Analysis of alcohol use as categorized by never, former and current drinkers did not show any statistically significant relationship with hypertension control (Table 4-10). Stratification by sex and categorical age found no statistically significant relationship between hypertension control and any of the alcohol usage categories.

Table 4-10 Alcohol use and uncontrolled hypertension

		Unweighted		Weighted			
	Alcohol use	N	uHTN %	N	uHTN %	Odds ratio	95% C.I.
All							
	Never	185	63	166	60	1	
	Former	393	72	398	63	1.11	0.70-1.75
	Current	1207	64	1332	62	1.08	0.72-1.62

4.4 Analysis of sociodemographic variables

It is well recognized that sociodemographic variables such as education, employment, income, language and area of residence affect health outcomes(71,72). These variables encompass subtle, but important aspects surrounding the delivery of health care such as access to health care, affordability of medications, knowledge of risk factors, and compliance with prescribed regimens. The relationship that these sociodemographic variables have with hypertension control is evaluated in the following analysis.

4.4.1 Area of habitation

During the initial selection process for the Canadian Heart Health Survey participants were stratified into 3 community sizes: metropolitan, urban, and rural.

Statistics Canada modified this variable slightly for analysis, grouping study participants into areas of greater than or equal to 10,000 (urban) or less than 10,000 people (rural). Ninety five percent of study participants had information regarding community size. The recommended design effect for the community size variable was 1.5.

Uncontrolled hypertension was 1.6 times as common in participants living in urban compared to rural areas (95% C.I. = 1.25-2.07) (Table 4-11). Both males and females who lived in urban areas were more likely to have uncontrolled hypertension than their rural counterparts, although this was not statistically significant for men. There was no evidence of effect modification or confounding by sex.

The mean age of participants living in urban areas was older than those living in rural areas (60 vs. 57 years, t-test: $p < 0.03$). For both rural and urban areas people with uncontrolled hypertension were older than those with controlled hypertension, although this was only statistically significant for urban areas.

Stratification by categorical age showed that urban inhabitants were once again more likely to have uncontrolled hypertension than rural inhabitants across all age strata, although this was not statistically significant for the middle age group (Table 4-11). There was no effect modification by categorical age. The Mantel-

Haenszel odds ratio for the three age strata was 1.43 compared to a crude odds ratio of 1.67. This represents a difference in beta coefficients of 22% suggesting that categorical age confounds the relationship between area of habitation and hypertension control. It was therefore appropriate to summarize the effect of categorical age on the relationship between area of habitation and uncontrolled hypertension with the Mantel-Haenszel odds ratio (O.R=1.43).

Table 4-11 Community size and uncontrolled hypertension

		Unweighted		Weighted			
	Area	N	uHTN %	N	uHTN %	Odds ratio	95% C.I.
All							
	Rural	709	64	519	54	1	
	Urban	1076	67	1377	65	**1.61**	1.25-2.07
OR_{MH}	Rural					1	
(sex strata)	Urban					**1.60**	1.24-2.06
$X^2_{Homogeneity}$ (sex strata)						$X^2 = 1.6$	$p > 0.10$ (df=1)
Male							
	Rural	293	67	298	56	1	
	Urban	454	71	577	63	1.36	0.96-1.93
Female							
	Rural	416	61	221	51	1	
	Urban	622	64	800	67	**1.91**	1.32-2.77
OR_{MH}	Rural					1	
(age strata)	Urban					**1.45**	1.12-1.88
$X^2_{Homogeneity}$ (age strata)						$X^2 = 3.41$	$p > 0.05$ (df=2)
Age 18-53							
	Rural	134	49	173	37	1	
	Urban	185	49	288	49	**1.65**	1.03-2.65
Age 54-67							

	Rural	310	63	231	64	1	
	Urban	427	68	704	67	1.13	0.77-1.65
Age 68-74							
	Rural	265	72	115	59	1	
	Urban	464	73	384	75	2.05	1.20-3.51

There were statistically significant differences in the employment characteristics of participants who lived in rural and urban areas. Specifically, rural participants were more often employed full time (41% vs. 25%; t-test: $p < 0.001$), and less often employed part-time (7% vs. 9%; t-test: $p < .001$). Employment confounded the relationship between area of habitation and uncontrolled hypertension (Δ ln (OR) = 16%).

There were also differences between rural and urban centers with regard to the first spoken language variable. Over 85% of participants who reported speaking Other language lived in rural areas (t-test: $p < .001$). The Mantel Haenszel odds ratio across the language strata is 1.51, compared to a crude odds ratio of 1.61 (Δ ln (OR) = 13 %).

In summary, uncontrolled hypertension was more common among people who live in urban areas, however part of this relationship was attributable to differences in age, and employment between urban and rural areas (i.e. confounding). The relationship between area of habitation and hypertension control was the same for men and women.

4.4.2 Education

Information regarding highest level of education attained by participants was gathered during the home interview. Categories of education were elementary or less ($\leq$ 6 years of education), some secondary (7 – 11 years of education), high school (12 – 15 years of education), university degree ($\geq$16 years of education). All of the study participants had information regarding education. The recommended design effect was 1.5.

Hypertension control was highest for those participants who had a university degree (Table 4-12). Using university as the referent category the odds ratios for participants with $\leq$elementary education, some secondary education, and high school education were 3.02 (95% C.I. = 1.77-3.90), 2.36 (95% C.I.= 1.60-3.48) and 2.63 (95% C.I. = 1.77-3.90), respectively. The Mantel Haenszel odds ratio controlling for level of education was 2.60. Chi-square test for homogeneity was not significant suggesting that the aforementioned odds ratios were not statistically different from the Mantel Haenszel odds ratio ($X^2_{Homogeneity} = 0.66$, $p > 0.10$). The interpretation of this was that the various education categories were different from the university degree category by a similar magnitude. Given the statistical homogeneity of the odds ratios, a dichotomous education variable was created which categorized participants according to whether or not they had a university degree. The crude odds ratio for the dichotomous education variable was 2.54 which was not significantly different from the Mantel Haenszel odds ratio of 2.60 (this represents a difference of 2% between the log odds ratios).

The relationship between education and hypertension was statistically significant for both men and women. The sex variable did not confound or modify () the relationship between education and hypertension control (Δ ln(OR) < 1%) ($X^2_{Homogeneity} = 0.3$; df=1, $p > 0.10$).

The average age of participants with a university degree was younger than the mean age of participants without a degree (53 versus 61, t-test: $p < .01$). Participants with uncontrolled hypertension were older in both education categories, although the difference was much greater among those with a university degree (t-test: $p < 0.01$). Among those with a university degree the average age of those with uncontrolled hypertension was 57 years compared to 49 years for those who were uncontrolled. Stratified analysis by categorical age showed that in the oldest age group uncontrolled hypertension was actually more common among those with university degrees - the opposite relationship from the crude (Table 4-12). The chi-square test for homogeneity was significant, but all of the difference can be attributed to difference in the oldest age group. The Mantel Haenszel odds ratio (2.06) of the age stratified analysis was significantly different from the crude odds ratio of 2.54 although once again all of this difference was accounted for by differences in the oldest age group. The estimate for the oldest age group exerted a large effect on the Mantel Haenszel and chi-square test for homogeneity. While the cell counts from which the odds ratios were calculated were acceptable by the Statistics Canada criteria for publication, the stability of the estimate for the oldest age group remains questionable because of the small numbers of persons with a university degree.

Given the small numbers of participants with a university degree stratifying by variables such as income adequacy, employment and area of habitation produced unacceptably small row totals according to Statistics Canada guidelines. For this reason effect modification by these variables could not be evaluated.

In summary, participants without a university degree were more likely to have uncontrolled hypertension, although some of this effect can be attributed to differences in age (those with a university degree were younger than those without). The relationship between education and hypertension control was the same for men and women.

Table 4-12 Education level and uncontrolled hypertension

	Level of Education	Unweighted N	Unweighted uHTN %	Weighted N	Weighted uHTN %	Odds ratio	95% C.I.
All							
	Degree	158	53	199	41	1	
	Highschool	567	62	696	65	2.63	1.77-3.90
	Secondary	978	66	807	62	2.36	1.60-3.48
	≤ elem.	277	70	286	68	3.02	1.91-4.79
All							
	Degree	158	53	199	41	1	
	No degree	1822	66	1788	64	2.56	1.78-3.69
OR_{MH} (age strata)	Degree					1	
	No degree					2.06	1.41 - 3.00
$X^2_{Homogeneity}$ (age strata)						$X^2 = 4.87$	$p > 0.05$ (df=2)
Age 18-53							
	Degree	320	50	386	49	1	
	No degree	52	40	97	28	2.49	1.36-4.53
Age 54-67							
	Degree	756	65	901	67	1	
	No degree	67	57	77	46	2.49	1.40-4.40
Age 68-74							
	Degree	746	73	500	71	1	
	No degree	39	64	25	80	0.54	0.15-1.92

4.4.3 Income adequacy

Income adequacy was a variable based on household income with additional consideration for the number of people living in the house. Eighty-six percent of study subjects had information on income. Categories for the income adequacy variable were: Low, Middle, and High. Low income was defined as income less than $12,000/year or income less than $24,999/year with 3 or more people in the household. Middle income was defined as income of $12,000 – 24,999/year for one person or $25,000 – 49,999 for households with two or more people. High income was defined as income of 25,000 – 49,999 for one person or income of greater than 50,000 for household with more than 2 people. The design effect recommended for income variables was 1.5.

Uncontrolled hypertension was more common among participants with low or middle income adequacy compared to those with high income adequacy with odds ratios of 1.57 (95% C.I = 1.12-2.21) and 2.12 (1.57-2.87), respectively (Table 4-13).

Sex exhibited statistically significant effect modification on the relationship between high versus low income and hypertension control (Table 4-13). Among women, uncontrolled hypertension was once again more common in the low and middle income categories as compared to high income. However, there was no difference in hypertension control for men with low income adequacy compared to men with high income adequacy. There was no evidence of confounding of sex on income adequacy.

The mean ages for the low, medium, and high income groups were 59, 62 and 53 years, respectively. Only the medium and high income groups (62 vs. 53 years) were different from one another with respect to mean age (t-test: $p < 0.01$). Participants with uncontrolled hypertension were older than those with controlled hypertension for all income adequacy categories. The categorical age variable did not modify the relationship between income adequacy and uncontrolled hypertension. However, there was a significant (>15%) change between the beta coefficients of the age stratified Mantel Haenszel odds ratio (1.32) and the crude odds ratio (1.57) suggesting that categorical age confounds the relationship between income and hypertension control.

Further analysis of the income variable was performed to evaluate its relationship with other variables concerned with socioeconomic status such as categorical education (elementary, some secondary, completed secondary, university degree), dichotomous education (presence or absence of a university degree) and type of employment (full time, part time, unemployed, retired, homemaker). Stratified analysis was inappropriate according to statistics Canada guidelines on minimum number of observations for reliable estimates. However, evidence of confounding was seen with both education variables as well as with employment. Specifically, the inclusion of categorical education to a logistic regression model decreased the beta coefficients for income by 38%. Inclusion of the employment variable decreased the beta coefficients by ~40%. The relationship between uncontrolled hypertension and income was no longer statistically significant when categorical age, education, and employment status were controlled.

Table 4-13 Income adequacy and uncontrolled hypertension

	Income Adequacy	Unweighted N	Unweighted uHTN %	Weighted N	Weighted uHTN %	Odds ratio	95% C.I.
All							
	High	256	54	374	50	1	
	Middle	963	66	901	68	**2.12**	1.57-2.87
	Low	517	66	442	61	**1.57**	1.12-2.21
OR_{MH}	High					1	
(sex strata)	Middle					**2.14**	1.57-2.90
	Low					**1.59**	1.12-2.24
$X^2_{Homogeneity}$ (sex strata)				Middle vs. High		$X^2 = 1.1$	$p > 0.10$
				Low vs. High		$X^2 = 5.9$	$p < 0.05$ (df=1)
Male							
	High	153	60	247	53	1	
	Middle	410	71	395	69	**1.96**	1.31-2.93
	Low	190	70	181	54	1.05	0.66-1.69
Female							
	High	112	46	126	42	1	
	Middle	62	553	506	66	**2.69**	1.65-4.38
	Low	327	65	260	65	**2.53**	1.48-4.31

In summary, uncontrolled hypertension was more common in the low and middle income groups, although much of this effect was attributable to differences in age, employment, and education. The relationship between lower incomes and uncontrolled hypertension was stronger for men than women.

4.4.4 Employment status

Subjects were categorized according to employment into full-time, part-time, unemployed, retired, and homemaker. Ninety-six percent of subjects had information regarding employment status. The recommended design effect was 1.5.

Uncontrolled hypertension was more common in all categories of employment compared to those working full time, although this was not statistically significant for those who were unemployed (Table 4-14). Tests of homogeneity for the categorical odds ratios were not significant suggesting that all categories were different from full time employment by a similar magnitude ($X^2_{Homogeneity} = 6.7$; $df=3$, $p > 0.05$).

All men who were not employed full-time had an increased likelihood of having uncontrolled hypertension. Uncontrolled hypertension was much more common in men employed part-time compared to men employed full time with an odds ratio of 7.18, although the confidence intervals were very wide (95% C.I. = 2.40-21.48). Interestingly, there was not a statistically significant difference in level of uncontrolled hypertension among women across the different categories of employment. Chi-square test for homogeneity was significant for many of the sex stratified employment categories, suggesting that there was effect modification by sex. Specifically, the association between working part time and having uncontrolled hypertension was different for men and women ($X^2_{Homogeneity} = 6.53$; df=1, $p < 0.01$). There was no evidence of confounding between sex and employment.

Table 4-14 Employment status and uncontrolled hypertension

		Unweighted		Weighted			
	Employment	N	uHTN %	N	uHTN %	Odds ratio	95% C.I.
All							
	Full-time	364	54	555	51	1	
	Part-time	129	69	145	77	**3.31**	1.97-5.55
	Unemployed	62	57	85	58	1.31	0.75-2.30
	Retired	833	69	670	64	**1.76**	1.33-2.33
	Homemaker	558	65	462	63	**1.69**	1.24-2.30
OR_{MH} for sex strata						**3.42**	2.01-5.84
						1.32	0.75-2.32
						1.79	1.34-2.40
						1.79	1.23-2.59
$X^2_{Homogeneity}$ (sex strata)				Part-time vs. full-time		**$X^2 = 6.53$**	$p < 0.01$ (df=1)
Male							
	Full-time	245	59	413	48	1	
	Part-time	53	79	44	86	**7.18**	2.40-21.48
	Unemployed	37	76	57	77	**3.58**	1.63-7.84
	Retired	458	72	330	66	**2.09**	1.45-3.01
	Homemaker	2	100	1	100	**	
Female							
	Full-time	119	44	142	60	1	
	Part-time	76	61	101	74	1.83	0.93-3.61
	Unemployed	25	28	28	18	-*	
	Retired	375	66	339	63	1.16	0.71-1.89
	Homemaker	556	64	460	63	1.15	0.72-1.85

* Statistics Canada advises that estimates based on counts of less than 30 were of unacceptable quality

** Table contained zero cells

Stratified analysis by categorical age and sociodemographic variables was not possible because of small numbers of participants in many of the categories. However, there were clear differences in the age and education distribution across the levels of employment (Table 4-15). Most importantly participants who worked full time were younger and had more years of education than other employment categories (t-test: $p < 0.01$). The relationship between employment was confounded by categorical age and education.

Table 4-15 Distribution of age and degree across levels of employment

Level of Employment	Mean age (yrs)	University degree (%)
Full time	49	19
Part time	57	10
Unemployed	54	14
Retired	67	6
Homemaker	62	5

In summary, uncontrolled hypertension was more common among participants who did not work full time although part of this effect was due to differences in ages and education between the categories. The relationship between employment and hypertension control was only statistically significant for men.

4.4.5 Language

Information regarding first language learned during childhood was collected from 95% of questionnaire respondents. The responses were grouped into three categories: English, French, and Other. The recommended design effect for the first language variable was 1.5.

People whose first language was classified as Other were 2.07 (95% C.I. = 1.52-2.81) times as likely to have uncontrolled hypertension than people whose first language was English. There was not a statistically significant difference in hypertension control between people whose first language was French and English (Table 4-16).

Stratification by sex showed that uncontrolled hypertension was much more common among men who reported Other language compared to English speaking men (O.R. = 4.25, 95% C.I. = 2.67-6.77). Hypertension control was the same among women who reported Other language and those who reported English (O.R. = 1.04 (95% C.I. 0.68 - 1.58). Sex confounded and modified the comparison of English speaking participants and Other speaking participants with respect to hypertension control. With regard to differences between participants reporting French and English it was found that uncontrolled hypertension was more common among French men compared to English men (O.R 1.68 95% C.I. =

1.07-2.61). There was no difference in hypertension control between French women and English women.

Uncontrolled hypertension was more common in those who reported Other language compared to English for all three age groups, but this was not statistically significant for the middle age group. The youngest age group showed the most marked difference between Other and English with an odds ratio of 4.08 (95% C.I. 1.82-9.12). The mean ages for English, French and Other language categories were 58, 60, and 62 years, respectively. Participants who reported Other language were statistically older than both English speakers and French speakers (t-test: $p < 0.001$). Categorical age confounded the relationships between language and hypertension control (Other vs. English: Δ ln(OR) = 15%, French vs. English: Δ ln(OR) = 60%). The relationship between language and hypertension control was different across age categories (i.e., effect modification) (Table 4-16).

Table 4-16 First language and uncontrolled hypertension

	Language	Unweighted N	Unweighted uHTN %	Weighted N	Weighted uHTN %	Odds ratio	95% C.I.
All							
	English	1141	64	1004	58	1	
	French	265	64	472	62	1.22	0.93-1.61
	Other	377	71	418	74	2.07	1.52-2.81
OR_{MH} for sex strata	English					1	
	French					1.20	0.91-1.58
	Other					2.08	1.53-2.84
$X^2_{Homogeneity}$ (sex strata)				French vs. English		$X^2 = 4.5$	$p < 0.05$
				Other vs. English		$X^2 = 18.2$	$p < 0.001$ (df=1)
Male	English	491	69	483	51	1	
	French	93	65	166	63	1.68	1.07-2.61
	Other	161	74	225	81	4.25	2.67-6.77
Female	English	650	61	521	64	1	
	French	172	63	306	62	0.91	0.64-1.31
	Other	216	68	193	65	1.04	0.68-1.58
OR_{MH} (age strata)	English					1	
	French					1.08	0.81-1.43
	Other					1.78	1.29-2.44
$X^2_{Homogeneity}$ (age strata)				French vs. English		$X^2 = 3.5$	$p > 0.05$
				Other vs. English		$X^2 = 7.0$	$p < 0.01$ (df=1)
18-53							
	English	240	48	334	41	1	
	French	41	44	76	31	0.99	0.53-1.85
	Other	38	63	52	38	4.08	1.82-9.12
54-67							
	English	451	55	388	66	1	
	French	127	63	291	63	0.87	0.59-1.28
	Other	158	71	255	71	1.27	0.84-1.93
68-74							
	English	450	72	282	66	1	
	French	97	73	105	77	1.77	0.94-3.33
	Other	81	72	110	80	2.06	1.08-3.91

Further stratified analysis of the language variable was performed to evaluate any interaction with other sociodemographic variables such as education, income, and area of habitation. Stratification by employment category was not done for statistical considerations related to very small cell counts.

Stratification by Education: English speaking participants had the highest percentage of university degrees (12%), and French speaking participants had the lowest (7%) (Table 4-17). Differences in hypertension control between participants reporting Other and English language was consistent over both education categories. Education did not confound or modify ($X^2_{Homogeneity} = 1.0$; df=1, $p > 0.10$) the comparison of Other language and English language with regard to hypertension control. Evidence of confounding was seen only in the comparison of hypertension control between French and English language.

Stratification by Income adequacy: English speaking people had the highest percentage of high income individuals (25%) and Other speaking people had the lowest (18%) (Table 4-17). Stratification by income did not exhibit modification of the relationship between language and hypertension control ($X^2_{Homogeneity} = 4.0$; df=2, $p > 0.05$). Income confounded the relationship between language and hypertension control.

Stratification by Area of habitation: Those who spoke Other language had the highest percentage of individuals living in an urban area whereas English speakers had the lowest (84% vs. 67%; t-test = p .001) (Table 4-17). No effect modification was seen of the relationship between language and hypertension control ($X^2_{Homogeneity}$ = 1.1; df=1, p > 0.10). Evidence of confounding was seen only in the comparison of hypertension control between participants reporting French and English language.

Table 4-17 Sociodemographic differences across language categories

	Urban	High income	University degree
English	671 (67%)	218 (25%)	118 (12%)
French	356 (75%)	82 (22%)	33 (7%)
Other	349 (84%)	66 (18%)	43 (10%)

In summary, the comparison of hypertension control between participants reporting Other language and English language found that uncontrolled hypertension was twice as common among participants who reported Other language, although part of this relationship was attributable to differences in age and income level (i.e., confounding). Sex modified the relationship such that only men displayed a statistically significant relationship between language and hypertension control.

In addition the comparison of hypertension control between participants reporting French language and English language showed no statistically significant difference in the level of uncontrolled hypertension. Grouped age confounded this relationship, although it did not modify the difference in uncontrolled hypertension between English and French. Differences in hypertension control between French and English was also confounded by income, education, and area of habitation.

4.5 Variables derived from data obtained during the clinic visit

Eighty-eight percent (1756/1989) of the study population completed a clinic visit in addition to completing the questionnaire. Anthropometric data, cholesterol, and two additional blood pressure measurements (for a total of 4) were collected during the visit. Baseline characteristics of the people who attended clinic were not significantly different from the study population in general.

4.5.1 Body Mass Index

The body mass index (BMI) is a measure of obesity calculated by dividing a person's weight in kilograms by their height in meters squared: Weight(kg)/ Height(m)^2. Ninety-nine percent of people who attended clinic had a value for BMI.

There was no statistically significant relationship between BMI and hypertension control nor was there a trend in odds ratios (Table 4-18). Sex stratified analysis did not show any relationship between BMI and uncontrolled blood pressure.

Stratification by categorical age showed no statistically significant and meaningful relationship between BMI and uncontrolled blood pressure.

Table 4-18 BMI and uncontrolled hypertension

		Unweighted		Weighted			
	BMI	N	uHTN %	N	uHTN %	Odds ratio	95% C.I.
All							
	≤24.9	403	63	358	56	1	
	25-26.9	309	60	350	63	1.33	0.87-2.03
	27-29.9	412	69	402	66	1.51	1.00-2.29
	30-34.9	396	64	475	65	1.46	0.98-2.17
	≥35	211	65	150	57	1.04	0.60-1.79
Male							
	≤24.9	130	66	108	57	1	
	25-26.9	149	67	185	69	1.67	0.83-3.33
	27-29.9	209	71	221	59	1.12	0.58-2.15
	30-34.9	195	70	208	61	1.18	0.61-2.30
	≥35	63	67	32	59	1.12	0.36-3.49
Female							
	≤24.9	273	61	249	55	1	
	25-26.9	160	54	164	55	1.02	0.59-1.79
	27-29.9	203	66	181	74	**2.22**	1.24-3.99
	30-34.9	201	57	267	68	**1.72**	1.03-2.85
	≥35	148	64	118	56	1.02	0.55-1.91

Analysis of a dichotomous BMI variable was also performed using a cutoff value of 27 (Table 4-19). Uncontrolled hypertension was more common in participants with BMI ≥27 although this was not statistically significant (O.R. = 1.22 , 95%

C.I. = 0.93 - 1.61). Stratification by sex showed effect modification ($X^2_{Homogeneity}$ = 5.5; df=1, $p < 0.05$) such that women with BMI ≥ 27 had a poorer hypertension control (O.R. = 1.64, 95% C.I. = 1.13 - 2.36). There was no statistically significant relationship between BMI ≥27 and hypertension control among men. Sex did not confound the relationship between BMI ≥ 27 and hypertension control.

Stratification by categorical age did not show any meaningful association between body mass index and hypertension control.

Table 4-19 Dichotomous BMI and uncontrolled hypertension

		Unweighted		**Weighted**			
	BMI	N	uHTN %	N	uHTN %	Odds ratio	95% C.I.
All							
	< 27	712	62	719	59	1	
	≥ 27	1019	66	1044	64	1.22	0.93-1.61
Male							
	< 27	279	67	299	64	1	
	≥ 27	467	70	469	60	0.84	0.55-1.28
Female							
	< 27	433	58	420	56	1	
	≥ 27	552	62	575	67	1.64	1.13-2.36

In summary, hypertension control was not different across all categories of BMI, except for women with body mass indices ≥ 27.

4.5.2 Waist to hip ratio

Waist to Hip ratio (WHR) is an assessment of abdominal obesity, a known cardiovascular risk factor. WHR was calculated by dividing the waist circumference by the maximal hip circumference. Seventy seven percent of respondents had a value for WHR.

Study participants who attended clinic were categorized as having either high waist to hip ratios ($\geq$0.9 for men and $\geq$0.8 for women) or low waist to hip ratios (<0.9 for men and <0.8 for women). Uncontrolled hypertension was 1.56 times more common in participants with high WHR compared to low WHR (95% C.I. = 1.09 - 2.23)(Table 4-20).

Stratification by sex showed that 88% of men and 67% of women were categorized as having high WHR. Men with high WHR (O.R. = 1.17) and women with high WHR (O.R. = 2.03) were both more likely to have uncontrolled hypertension, although this was only statistically significant for women. Homogeneity testing was not significant meaning that the odds ratios for males and females were not different from the Mantel Haenszel odds ratio of 1.73 ($X^2_{Homogeneity}$ = 1.71; df=1, $p > 0.10$). Given the discrepancy between the Mantel Haenszel odds ratio (1.73) and the crude odds ratio (1.56), sex was likely a confounder.

Stratification by age did not produce any statistically significant relationship between WHR and hypertension control.

Table 4-20 WHR and uncontrolled hypertension

	WHR	Unweighted N	Unweighted uHTN %	Weighted N	Weighted uHTN %	Odds ratio	95% C.I.
All Subjects							
	Low	222	61	329	55	1	
	High	669	69	1028	66	**1.56**	1.09-2.23
OR_{MH}	Low					1	
(sex strata)	High					**1.73**	1.20-2.51
$X^2_{Homogeneity}$ (sex strata)						$X^2 = 1.71$	$p > 0.10$ (df=1)
Male							
	Low	51	67	74	57	1	
	High	330	71	517	61	1.17	0.58-2.36
Female							
	Low	171	60	256	55	1	
	High	339	67	511	71	**2.03**	1.30-3.15
OR_{MH}	Low					1	
(age strata)	High					**1.53**	1.20-2.51

$X^2_{Homogeneity}$ (age strata)						$X^2 = 2.35$	$p > 0.10$ (df=1)
Age 18-53							
	Low	43	42	93	26	1	
	High	89	51	248	44	2.26	0.96-4.63
Age 54-67							
	Low	93	61	169	63	1	
	High	279	70	536	72	1.53	0.92-2.56
Age 68-74							
	Low	86	71	73	75	1	
	High	301	73	260	74	0.92	0.39-2.16

In an attempt to assess any dose-response relationship between WHR and proportion of uncontrolled hypertension, WHR was stratified into 0.70-0.79, 0.80-0.89 and ≥0.90. Among women, the middle and highest WHR categories had more uncontrolled hypertension than the lowest category with odds ratios of 1.97 (95%C.I.= 1.23-3.17) and 2.17 (95%C.I.= 1.18-3.98), respectively (Table 4-21). The 95% C.I. for largest WHR category completely brackets the 95% C.I. for the intermediate WHR category indicating that the two odds ratios were not different from one another and that there was no dose response. None of the WHR categories were statistically significant for men.

Table 4-21 WHR in females and uncontrolled hypertension

		Unweighted		**Weighted**			
	WHR	N	uHTN %	N	uHTN %	Odds ratio	95% C.I.
Females							
	.70-.79	171	60	256	55	1	
	.80-.89	239	63	355	70	**1.97**	1.23-3.17
	≥.90	100	76	155	73	**2.17**	1.18-3.98

In summary, high waist to hip ratios were associated with poorer levels of hypertension control, although this was only statistically significant for women.

Table 4-22 Summary of bivariate results

1) Cardiovascular variables

Variable		Odds ratio	Confidence Interval
Diabetes		**2.99**	1.92-4.67
Sex			
	Male	1	
	Female	1.08	0.90-1.30
Grouped age			
	18-53	1	
	53-67	**2.36**	1.89-2.95
	68-74	**3.08**	2.37-3.99
Regular smoker			
	No	1	
	Yes	0.79	0.61-1.02
Cigarettes per day			
	Not regular smoker	1	
	1-10 per day	**0.29**	0.17-0.50
	11-25 per day	0.80	0.55-1.16
	>25 per day	**3.09**	1.49-6.43
Alcohol use			
	No alcohol	1	
	1 drink/day	0.92	0.38-2.26
	2 drinks/day	0.83	0.32-2.16
	3 drinks/day	1.06	0.42-2.70
Sedentary lifestyle			
	No	1	
	Yes	1.06	0.85-1.32
Follow up			
	< 6 months	1	
	$\geq$ 6 months	0.75	0.49-1.19

2) Sociodemographic variables

Variable		Odds ratio	Confidence Interval
First language			
	English	1	
	French	1.22	0.93-1.61
	Other	2.07	1.52-2.81
Area			
	Rural	1	
	Urban	1.61	1.25-2.07
Income level			
	High	1	
	Middle	2.12	1.57-2.87
	Low	1.57	1.12-2.21
Employment			
	Full time	1	
	Part time	3.31	1.97-5.55
	Unemployed	1.31	0.75-2.30
	Retired	1.76	1.33-2.33
	Homemaker	1.69	1.24-2.30
Education			
	University degree	1	
	No university degree	2.56	1.78-3.69
Education			
	University degree	1	
	High school	2.63	1.77-3.90
	Secondary	2.36	1.60-3.48
	<elementary	3.02	1.91-4.79

Chapter 5 Multivariate analysis

5.1 Logistic regression model

Unconditional logistic regression modeling was used to further evaluate associations between patient variables and uncontrolled hypertension. All people who completed a questionnaire in the Canadian Heart Health Survey, and who were currently taking antihypertensive medication were included in the analysis.

5.2 Variable selection

Initial variable selection was based on statistical and clinical significance. All clinically important variables as well as variables with p-values less than 0.25 from the bivariate analysis were included in the model building process (Table 4-19). There was no significant collinearity between variables using a 0.75 cutoff as recommended by Hosmer and Lemeshow(68).

Two variables measuring smoking habits among participants were candidates for multivariate analysis: regular smoking status and number of cigarettes per day. Because the variables were measuring the same characteristic only one could be used in the model building process. The cigarettes per day variable was selected because it was significant in the bivariate analysis whereas the regular smoking variable only had a p-value = 0.692.

The sex variable was not significant in the bivariate analysis with a p-value of 0.38 but was felt to be clinically important and therefore was included in the multivariate analysis. In addition it was an important effect modifier for many other variables in the bivariate analysis so separate logistic regression models were constructed for men and women.

The variable regarding waist to hip ratio (WHR) was not selected for multivariate analysis despite its significance in the bivariate analysis. The reason for this is related to the different weights that Statistics Canada produced for clinic derived variables and questionnaire derived variables. As outlined in chapter 3, Statistics Canada calculated two weights for the database: one weight for clinic variables and one weight for questionnaire variables. In order to include WHR in a logistic regression model with other questionnaire variables one would have to apply the questionnaire weight to WHR. It would not be appropriate to analyze a clinic variable using questionnaire weights because of important differences in the calculation of clinic and questionnaire weights. A comparison of questionnaire weighted versus clinic weighted bivariate results for clinic variables showed large discrepancies in point estimates. It would therefore be inappropriate to apply the questionnaire weights to clinic variables. As a result waist to hip ratio was not included in the model building process.

5.3 Variable format

The variables considered for multivariate analysis were appraised for the clinical and statistical appropriateness of their respective categories. Most variables remained in the same format (categories) in which they were provided by Statistics Canada, with three notable exceptions.

The variable regarding first spoken language was initially trichotomous (English, French, and Other), but was dichotomized into English+French and Other language after the bivariate results were interpreted. The rationale for dichotomizing language was three fold: 1) there was not a statistically significant difference in uncontrolled hypertension between English speakers and French speakers; 2) The odds ratio from the comparison of English versus Other (2.07) is not meaningfully different than the odds ratio of English+French and Other (1.94); 3) the inclusion of the dichotomous language variable in the multivariate model improved the power of the model without sacrificing any meaningful information.

The education variable initially had 4 categories: <elementary education, some secondary education, completed high school, and university degree. Once again scrutiny of the bivariate results showed that categories of education were different from the referent category (university degree) by a similar magnitude (i.e., non-significant chi-square test for homogeneity). For this reason the education variable was dichotomized based on presence or absence of a university degree. It was felt

that inclusion of the multichotomous form of the education variable would have added little extra information compared to the dichotomous form, but would have unnecessarily lowered the power of the final model.

The number of cigarettes smoked per day was shown to be significantly associated with hypertension control. Because of the relatively few people in the ≥25 cigarettes per day category, a new variable was created based on the following categories: non smokers, 1-10 cigarettes per day, and ≥10 cigarettes per day.

Table 5-1 Variables selected for multivariate analysis

Variable		Unadjusted odds ratio	95% Confidence interval
1) Cardiovascular variables			
Diabetes			
	No	1	
	Yes	**2.99**	1.92-4.67
Sex			
	Male	1	
	Female	1.08	0.90-1.30
Grouped age			
	18-53	1	
	53-67	**2.36**	1.89-2.95
	68-74	**3.08**	2.37-3.99
Cigarettes per day			
	Non smoker	1	
	1-10 cigarettes/day	**0.29**	0.18-0.47
	≥10 cigarettes/day	1.12	0.83-1.52
Follow up			
	< 6 months	1	
	> 6 months	0.75	0.49-1.19

2) Sociodemographic variables

First language		
English	1	
French	**1.22**	0.93-1.61
Other	**2.07**	1.52-2.81
Area		
Rural	1	
Urban	**1.61**	1.25-2.07
Income level		
High	1	
Middle	**2.12**	1.57-2.87
Low	**1.57**	1.12-2.21
Employment		
Full time	1	
Part time	**3.31**	1.97-5.55
Unemployed	1.31	0.75-2.30
Retired	**1.76**	1.33-2.33
Homemaker	**1.69**	1.24-2.30
Education		
University degree	1	
No university degree	**2.56**	1.78-3.69

5.4 Model building

A manual, backward, stepwise logistic model building technique, as described by Hosmer and Lemeshow(68), was used to construct an unconditional logistic regression model. Variable significance was based on p-values for the Wald statistic as well as the chi-square test for changes in the log likelihood (-2ln(L)). Confounding was defined as a change of ≥15% in the beta coefficients of variables remaining in the model after deletion of a variable.

The model building process proceeded as follows:

Step 1: All participants with missing values were deleted to ensure comparability between logistic regression models. Of the 10 variables included in the multivariate analysis (Table 5-1) five had response rates of 100%, three had response rates of 95% and two had response rates of 85%. Deletion of participants with missing values reduced the number of participants from 1989 to 1481 (unweighted).

Step 2a: All variables (Table 5-1) selected for multivariate analysis were entered into a logistic regression model. The variable with the largest Wald statistic p-value was selected for deletion in the next step.

Step2b: Each variable removed was assessed for confounding. Significant confounding was defined as a change in one or more beta coefficients between the model with and without the variable. Variables that were important confounders were not removed from the model irrespective of their Wald or chi-square p-value.

Step 2c: The impact of the deleted variable on the overall model was assessed using the difference in log likelihood between the model with the variable and the model without the variable. Variables were only deleted from the model if the p-value for the change in log likelihood was >0.05.

Step 3: The next variable to be deleted was selected by assessing the largest Wald statistic p-value among the variables that remained in the model. Confounding and changes in log likelihood were evaluated as outlined in steps 2b and 2c.

Step 4: Step 3 was repeated until all non-significant variables were deleted, or until the removal of a variable produced a significant ($p < 0.05$) change in the log likelihood (Tables 4-22 to 4-25). The remaining model was considered to be the preliminary main effects model.

Step 5: Interaction terms were assessed by compiling a list of all potential interaction terms involving variables in the preliminary main effects model. Clinically important interaction terms were then selected from this list. Because of the difficulty in interpreting models containing interaction terms, more rigorous standards for inclusion of these terms were applied. Specifically, interaction terms were only included if most levels of the interaction term (i.e., design variables) were significant, they had highly significant Wald statistics, and they produced a significant change in the -2ln(L).

Step 6: The Pearson chi-square goodness of fit test was used to assess the overall fit of the model. This was the final model.

5.5 Final logistic regression model

The variables income adequacy, sex, and follow up were removed from the model by backward elimination. Removal of the sex variable caused a 72% change in the beta coefficient associated with the homemaker vs. full time employed design variable. The large change is related to the fact that there was only 1 male who was categorized as a homemaker, and therefore sex is not truly a confounder and can safely be removed from the model.

The preliminary main effects model included the following variables: diabetic status, grouped age, education level, type of employment, native language and area of habitation (Table 5-2). No clinically relevant interaction terms satisfied the criteria for inclusion in the model (section 5.4, step 5). The Hosmer-Lemeshow goodness of fit was not significant ($p<0.5461$).

With no significant interaction terms, the final logistic regression model is the same as the preliminary main effects model (Table 5-2).

The following patient characteristics were associated with uncontrolled hypertension: diabetes, smoking more than 10 cigarettes/day, older age, not having a university degree, living in an urban area, having a native language other than English or French, working part time and older age.

Table 5-2 Final logistic regression model

Variable		Odds Ratio (95% C.I.)
Diabetic status	No	1
	Yes	**3.50** (2.23-5.51)
Grouped age	18-53	1
	54-67	**2.36** (1.62-3.45)
	68-74	**3.46** (2.09-5.72)
Cigarettes per day	Non-smoker	1
	1-10 cigarettes/day	**0.34** (0.16-0.74)
	≥10 cigarettes/day	**1.74** (1.14-2.63)
Native language	English/French	1
	Other	**1.87** (1.30-2.70)
Education level	University degree	1
	No degree	**2.00** (1.26-3.17)
Area of habitation	Rural	1
	Urban	**1.72** (1.27-2.32)
Employment	Full-time	1
	Part-time	**2.76** (1.48-5.15)
	Unemployed	0.89 (0.45-1.77)
	Retired	0.71 (0.46-1.09)
	Homemaker	0.80 (0.52-1.22)

5.6 Male and female logistic regression models

Separate logistic regression models were constructed for men and women to evaluate the effect modification that the sex variable exhibited in the bivariate analysis. The logistic regression models were created using the same steps as the crude logistic regression model.

Variable selection:

Variables selected for the male and female logistic regressions are based on statistical significance ($p<0.25$ from sex stratified analysis) as well as clinical relevance. The variable concerned with sedentary lifestyle was thought to be clinically important, and was significant in the sex stratified analysis (males only). For this reason, the sedentary lifestyle variable was included in the base model for both male and female logistic regressions. The list of variables included in the multivariate model building process can been seen in Table 5-3.

Table 5-3 Variables selected for male and female multivariate model building

Variables
• Diabetes
• Grouped age
• Cigarettes per day
• Time since follow up
• Sedentary lifestyle
• Area of habitation
• Education level (University or not)
• Employment
• Native language
• Income adequacy

Variable format:

The same formats were used as outlined in section 5.3 with one exception: there was only one male in the homemaker category of employment so a new employment variable was created for men that was identical to the original, except that it did not have a homemaker category.

Variable and model significance:

Significance was assessed using p-values for the Wald statistic and chi-square test for change in -2ln(L).

Model building process for men:

The model building process for the male logistic regression began with ten variables. The sedentary lifestyle variable was not significant in the multivariate model but remained in the model because it confounded the beta coefficients grouped age, employment, and cigarettes per day. University education and area of habitation were both removed from the model even though they both caused a >15% change in one of the beta coefficients in the model. In both cases the beta coefficients that were changed were not themselves significant and the change in beta was not felt to be clinically important. All remaining variables (other than sedentary lifestyle) were significant according to the Wald statistic and caused a significant change in the -2ln(L) if removed (Table 5-4). No interaction terms met the criteria for inclusion (step 5, section 5.4). The Hosmer-Lemeshow goodness of fit test was significant ($p<.0002$).

The logistic regression for male participants identified the following variables as being associated with uncontrolled hypertension: age, diabetes, employment, education, income, language, time since follow up, and cigarette smoking (Table

5-4). There were four additional variables included in the male logistic regression that were not part of the combined model: sedentary lifestyle, cigarette smoking , income adequacy, and time since follow up. Area of habitation did not achieve significance in the male logistic regression model.

It is also important to note that some of the variables common to both the male and combined logistic model had important differences in the nature or magnitude of their associations to uncontrolled hypertension. For example, cigarette smoking in the male logistic regression showed much better blood pressure control in the 1-10cigs/day smokers, and no significant decline in hypertension control in the ≥25 cigs/day group. The relationship between income adequacy is also changed for men compared to the bivariate results. For men, low and medium income were associated with improved blood pressure control, the opposite relationship to what was seen in the bivariate analysis.

Model building process for women:

The model building for the female logistic regression process began with the same ten variables used in the male logistic regression. Manual, backward elimination was preformed as outlined in section 5.4 until all non-significant variables were removed from the model (Table5-4). There were no clinically significant interaction terms that met the criteria for inclusion in the model (step 5 section 5.4). The Hosmer-Lemeshow goodness of fit test was significant ($p<.008$).

The logistic regression for female participants identified the following variables as being associated with uncontrolled hypertension: age, diabetes, employment, education, income, cigarette smoking, sedentary lifestyle, and area of habitation (Table 5-4). Income adequacy and sedentary lifestyle were both significant in the female logistic model, but not in the combined model. Language first spoken was notably absent from the female logistic model. The fact that the area of habitation variable was included in the female only model, but not in the male only model is supported by a previous study(70).

Generally the variables common to both the female and combined logistic models were similar with respect to the direction and magnitude of association, with a few exceptions. For example, part-time employment was not statistically different from full-time employment in the female model whereas it was significantly associated with uncontrolled hypertension in the combined and male logistic models.

Table 5-4 Comparison of logistic regression models

Variable		Odds Ratio (95% C.I.) Combined	Male	Female
Diabetic status	No	1	1	1
	Yes	**3.50** (2.23-5.51)	**3.53** (1.75-7.16)	**3.23** (1.70-6.13)
Grouped age	18-53	1	1	1
	54-67	**2.36** (1.62-3.45)	**2.00**(1.14-3.53)	**2.51** (1.37-4.60)
	68-74	**3.46** (2.09-5.72)	1.75 (0.72-4.24)	**4.27** (2.10-8.66)
Cigarettes/day	Non-smoker	1	1	1
	1-10 cigs/day	**0.34** (0.16-0.74)	**0.06** (0.14-0.28)	1.26 (0.39-4.02)
	≥10 cigs/day	**1.74** (1.14-2.63)	1.11 (0.62-2.00)	**3.10** (1.58-6.09)
Education level	No degree	1	1	1
	University degree	**2.00** (1.26-3.17)	**2.38** (1.28-4.43)	**3.91** (1.70-8.99)
Employment	Full time	1	1	1
	Part time	**2.76** (1.48-5.15)	**4.89** (1.53-5.64)	1.28 (0.52-3.17)
	Unemployed	0.89 (0.45-1.77)	**2.33** (0.90-5.98)	**0.10** (0.20-0.51)
	Retired	0.71 (0.46-1.09)	1.51 (0.73-3.12)	**0.34** (0.16-0.73)
	Homemaker	0.80 (0.52-1.22)	---	**0.38** (0.19-0.78)
Area	Rural	1	---	1
	Urban	**1.72** (1.27-2.32)		**1.65** (1.04-2.61)
Native language	English/French	1	1	
	Other	**1.87** (1.30-2.70)	**3.92** (2.12-7.28)	---
Income adequacy	High	---	1	1
	Medium	---	0.68 (0.39-1.18)	**1.94** (1.10-3.43)
	Low	---	**0.42** (0.22-0.80)	**2.31** (1.24-4.31)

Sedentary lifestyle	No	---	1	1
	Yes		1.25 (0.78-2.00)	**1.59** (1.06-2.37)
Time since follow up	<6months	---	1	
	>6months	---	**0.41** (0.19-0.84)	---

Chapter 6- Discussion and conclusion

Analysis of participants in the Canadian Heart Health Study (CHHS) who were currently on pharmacologic antihypertensive treatment showed that 65% (1,230) did not have their blood pressure controlled at the ≤140/90 mmHg level(2). Bivariate analysis and logistic regression were performed to identify variables associated with inadequate response to therapy.

6.1 Logistic results

The final logistic regression model identified the following variables to be associated with uncontrolled hypertension: age, diabetes, urban residence, no university degree, part-time employment, heavy cigarette smoking, and first language other than English or French (Table 5-2). Variables that were not associated with uncontrolled hypertension included: sex, income level, alcohol use, time of last blood pressure measurement and sedentary lifestyle.

Generally the results of the logistic regression were very similar to the bivariate results, both in the variables included in the final model, as well as their associated odds ratios. Income adequacy was the only variable that was statistically significant in the bivariate results that did not achieve statistical significance in the logistic model. The exclusion of the income adequacy variable did not come as a surprise given the high degree to which it was confounded in the bivariate results (i.e., income confounded by categorical age, education and employment). Also of note, the sex variable did not achieve statistical significance throughout the model building process and was consequently eliminated. However, in the bivariate results sex exhibited clinically important effect modification across a wide range of variables (i.e., categorical age, smoking, sedentary lifestyle, follow up, employment, first language, and income adequacy). For this reason separate logistic regression models were constructed for men and women and are discussed further in section 6.2.

Diabetes exhibited a strong and consistent association with uncontrolled hypertension in both the bivariate and logistic analyses. Diabetics were roughly three times more likely to have uncontrolled hypertension than non-diabetics irrespective of age, sex, or sociodemographic category. The relationship between diabetes and uncontrolled hypertension has been described previously(61). Patients with hyperinsulinemia and glucose intolerance have decreased responsiveness to antihypertensive therapy, independent of obesity(24,36) The lack of statistical association between body mass index and uncontrolled hypertension in the present study supports the hypothesis that glucose intolerance and hyperinsulinemia play a direct role in reducing responsiveness to antihypertensive medications. However, given the association between obesity and development of type II diabetes, one might have predicted that body mass index would have been significantly associated with uncontrolled hypertension if only via the causal chain of diabetes. Better characterization of the relationship between diabetes, obesity and uncontrolled hypertension would be useful areas of further study.

Older participants were consistently shown to have more uncontrolled hypertension than younger participants in both the bivariate and logistic analyses. In addition categorical age was an important confounder for many variables in the bivariate analysis (i.e., sex, area, education, income, and language). The relationship between age and uncontrolled hypertension has been somewhat inconsistent in the literature. In many such studies there was no association between increased age and uncontrolled hypertension(12-14,41). In several studies, youth has been associated with uncontrolled hypertension(47,62,70) as well as poor compliance with treatment regimens(48). Conversely, Degoulet et al. studied 1,126 hypertension clinic patients and found that older patients were more likely to have uncontrolled hypertension than younger patients(55). The reasons for such inconsistencies are not straightforward. The reality may be that both extremes of adult age are associated with high rates of uncontrolled hypertension, but for different reasons. Perhaps young hypertensives have high rates of uncontrolled hypertension secondary to issues of non-compliance(47,51,64) whereas older hypertensives have high rates of uncontrolled hypertension for reasons related to increased frequency of concomitant disease that complicates antihypertensive therapy (e.g., renal vascular disease).

In this study, participants who lived in urban centers had more uncontrolled hypertension than those who lived in rural areas. Barton et al. looked at 5,237 participants from urban and rural Alabama, U.S.A and found that rural women had more uncontrolled hypertension than their urban counterparts, and that the reverse was true for men(70). One might have predicted that urban areas would have better hypertension control because of presumed greater accessibility to health care services. This was not borne out in the analysis, raising the question of what differences exist between rural and urban inhabitants. In the present study, there were important and statistically significant differences in the characteristics of participants who lived in rural and urban areas. Specifically, participants living in rural areas were younger (mean age: 57 vs. 60 years, t-test: $p < 0.03$), more often employed full time (41% vs. 25%; t-test: $p < 0.001$), and less often employed part-time (7% vs. 9%; t-test: $p < .001$). In addition, the vast majority of participants who reported Other language lived in urban areas (85% vs. 15%; t-test: $p < .001$). All of these differences were associated with decreased blood pressure control. The area of habitation variable was confounded by age and employment, and the language variable produced a 13% change in the beta coefficient of the area variable (confounding was defined as: Δ ln (OR) >15%). While, age, employment and language likely accounted for some of the association between urban living and uncontrolled hypertension, area of habitation was still significantly associated with uncontrolled hypertension after controlling for these variables in the logistic regression. Therefore, differences in lifestyle (i.e., type of full or part-time employment) between the two areas of habitation, rather than accessibility to health care, were most likely responsible for the different levels of blood pressure control.

The relationship between first spoken language and uncontrolled hypertension has not been previously described in the literature. In the present study, uncontrolled hypertension was more common among people whose first spoken language was reported as Other. This was particularly true for young men who reported Other language. This was an important finding because it could mean that Canadians who do not speak English or French as a first language (i.e., first or second generation immigrants) have important barriers to accessing health care. It would be prudent to explore this area further in order to better characterize the immigrant population with regard to patterns of health care utilization in general, and specifically hypertension control.

Participants who worked part time were more likely to have uncontrolled hypertension than those who worked full time. The employment variable was the only variable in the logistic regression model to undergo meaningful change to its odds ratios as compared to the bivariate analysis. Specifically, all employment categories were more likely to have uncontrolled hypertension than those employed full time in the bivariate analysis. In the final logistic model, only part time employment was associated with increased levels of uncontrolled hypertension whereas the remaining categories were associated with improved blood pressure control compared to those employed full-time. However, only the comparison between part-time and full-time employment achieved statistical significance. The relationship between part-time employment and uncontrolled hypertension has not been previously reported in the literature. Isaksson et al. found that those employed in areas of manual labor had higher levels of uncontrolled hypertension, although distinction was not made between full and part-time(61). Employment was likely a proxy measure for socioeconomic status which has been shown to be a risk factor for both uncontrolled hypertension(34,62) and noncompliance(53). People who were employed part time may represent a socioeconomically disadvantaged group who were at a greater risk for health complications, such as uncontrolled hypertension. However, it is more likely that those employed part-time were a heterogeneous subset of the population, with multifactorial reasons for inadequate response to therapy. It is therefore unlikely that all persons who work part time will be at greater risk for having uncontrolled hypertension. More detail as to the specific type of part time employment, as well as other measures of socioeconomic status associated with uncontrolled hypertension would be helpful to clarify this issue.

Level of education was consistently associated with uncontrolled hypertension in both the bivariate and logistic analyses. Participants who had did not have a university degree (90%) were more likely to have uncontrolled hypertension than those who had a university degree. The association between greater number of years of education and improved hypertension control has been supported in the literature(12,61,62). Differences in education, like employment, likely encompass a whole range of intangible socioeconomic factors that influence health care outcomes, including response to antihypertensive treatment.

The relationship between cigarette smoking and uncontrolled hypertension was somewhat complicated, in that it was associated with improved blood pressure control in low doses (1-10 cigarettes/day) and associated with poor blood pressure control in higher doses ($\geq$ 25 cigarettes/day). In the bivariate analysis, this relationship was only statistically significant for men. The lower levels of uncontrolled hypertension associated with smoking 1-10 cigarettes per day was statistically significant even after controlling for all the variables in the multivariate model. The interpretation of this relationship is unclear, but it is likely a result of an unknown confounder rather than any protective effect of low level cigarette smoking. The relationship between cigarette smoking and increased levels of uncontrolled hypertension has been described previously in the literature(54,69). McAlister et. al. reported that the vasopressor effects of cigarette smoking could transiently increase a smoker's blood pressure, counteracting the effect of their blood pressure medications(37). The vasopressor property of nicotine was the rationale for the recommendation from JNC VI to abstain from smoking for 30 minutes prior taking a blood pressure reading(3). In addition, current smoking has also been shown to be a predictor for non-compliance with antihypertensive treatment and follow up(55). It was unclear as to why low dose use of cigarettes was associated with lower levels of uncontrolled hypertension, and further study of this area is warranted.

6.2 Male and female logistic models

Different logistic regression models were constructed for males and females because of the many instances of effect modification by the sex variable in the bivariate analysis. Generally, the male and female models were more inclusive than the combined model, but both had highly significant Hosmer-Lemeshow goodness of fit tests. The male and female logistic regressions showed important differences from each other as well as from the combined logistic regression (Table 5-4).

One of the important differences between the male and female logistic models was that the language variable was not significant for women, but highly significant for men. Among participants who reported other language, men were twice as likely to have uncontrolled hypertension than women. It would seem that traditional stereotypes of male under-utilization of health care were at work in immigrant populations.

Another important difference between male and female logistic models was the effect that lower income has on hypertension control. For women, lower income was strongly associated with poor blood pressure control, but this effect was not seen among men. It may be that socioeconomic factors played a more prominent role in hypertension control for women as compared to men.

Studies on hypertension control that have specifically looked at differences between men and women have identified a small number of characteristics. Men have generally been shown to have a greater burden of uncontrolled hypertension(12,41,46) and lower levels of compliance than women(53). Many of the studies from the United States have shown that young black men in particular have increased rates of uncontrolled hypertension, noncompliance, and loss to follow up(48,62). Uncontrolled hypertension has also been shown to be higher among urban men compared to rural men(70).

Among women, young age, black race, and lower socioeconomic status were all associated with poor blood pressure control(62). In contrast to men, women who lived in rural areas had more uncontrolled hypertension than their urban counterparts(70). Infrequent visits to the doctor's office was also found to be associated with uncontrolled hypertension for women(47).

The results of the male and female multivariate analysis from this study show some similarities with previous findings, but in particular were different with regard to age and language.

6.3 Strengths and limitations

The Canadian Heart Health Study (CHHS) was unique in that it provided the first population level assessment of hypertension control among Canadian citizens. One of the major strengths of this study was this widespread generalizability. The sampling design incorporated several strategies to ensure that the results of this study were applicable to Canadian adults of all ages. The sampling frame included all non institutionalized Canadians, aged 18-74, who had a provincial health care insurance number. There was a small subgroup of Canadians who were not included in the sampling frame because they either did not have a provincial health care insurance number or their address with the provincial health care system was not current. This subgroup likely represents a more transient and higher risk group whose absence, if anything, would decrease the magnitude of association between patient variables and uncontrolled hypertension.

The method by which hypertensive status was obtained was another strength of this study. Eighty-eight percent of the study population had four blood pressure measurements (2 at the home interview and 2 at the clinic) performed by trained study personnel. The familiar setting for the patient during the home interview as well as the multiple blood pressure readings minimizes the chances of spurious readings caused by pseudo-hypertension. However, a potential bias results from this protocol of blood pressure measurement because study personnel were aware of the respondent's first blood pressure reading before administering the questionnaire. This could have lead to differential misclassification bias of questionnaire answers or the second blood pressure reading.

A major limitation of this study was that it failed to collect important information on factors relating to inadequate response to therapy. For example, no data were collected that specifically addressed compliance with prescribed medications. Non-compliance has generally been accepted as a major contributing factor in inadequate response to therapy(14,45,54,64). Morisky has developed four yes/no questions designed to screen for medication compliance that would have been a valuable addition to the questionnaire(73). The absence of information on compliance was an important omission in the generation of a profile of the uncontrolled hypertensive. Furthermore, its absence my have resulted in the inclusion of variables in the final logistic regression model that were proxy measures for compliance. Although it should be noted that variables typically associated with noncompliance such as smoking status, young age, infrequent doctors visits and male sex were not clearly and consistently associated with poor hypertension control(48,51,55) .

Another problem with the CHHS was the lack of information collected on the type, frequency, or dosage of medications respondents had been prescribed. Many drug variables have been shown to be associated with uncontrolled hypertension such as insufficient drug regimens(41,46,74) and drug interactions(15,45,52). Drug variables likely contributed significantly to inadequate response to therapy and therefore their inclusion would have made the final model more reflective of patients with uncontrolled hypertension.

The definition of hypertension used in the CHHS poses another potential problem in interpreting the study results. The CHHS chose a definition of hypertension (≥140/90 mmHg) that was, at the time, relatively aggressive. A potential problem arises because there was a general lack of consensus on treatment guidelines during the period of data collection (1986-1992). Many guidelines at the time suggested initiating treatment when systolic blood pressure was greater than 160 mmHg. Thus people with isolated systolic hypertension – a predominantly geriatric problem – could have been treated 'successfully' to their target blood pressure (<160 mmHg) but would have still been characterized as hypertensive by CHHS researchers if their systolic blood pressure was ≥140 mmHg. The net effect was that patients with ISH -usually older – may have been misclassified as treated and uncontrolled, and could possibly account for the some of the observed relationship between age and uncontrolled hypertension. Generally speaking, this type of misclassification would have lessened the differences between those with uncontrolled blood pressure and those with controlled blood pressure (i.e., bias towards the null).

Lastly, the complexity of the sampling design precluded the creation of a multivariate model that included variables derived from both clinic and questionnaire data. It would have been informative to evaluate variables such as waist to hip ratio and body mass index in a multivariate analysis, particularly in the female logistic regression analysis.

6.4 Conclusions

The variables associated with uncontrolled hypertension seen in the Canadian Heart Health Study were generally similar to related studies that have been done over the 2 decades and in different countries. The notable exception to this was the variable relating to first language spoken. Its association with uncontrolled hypertension could represent a barrier to health care for foreign born Canadians. Further study of hypertension control within immigrant populations would be useful to better characterize the problem and to design specific interventions to improve control in this unique population.

Perhaps the most important message to have come out of this analysis was that hypertension control among diabetics was poor. This poor control occurs despite the increased contact with the health care system that one would assume a patient with diabetes would have. It is important for general practitioners to be aware that diabetics with hypertension may require higher doses, or a greater number of antihypertensive agents to control their blood pressure. In addition, this study accentuates the need for general practitioners to redouble their efforts to identify hypertension in their diabetic patients and to manage that hypertension aggressively.

Overall the results of this study can be used by general practitioners to identify patients at high risk for inadequate response to therapy and bring time and resources to bear to prevent this from occurring. Improving control of hypertension will not only reduce the incidence of hypertensive complications and their attendant health care costs, but it will also lower mortality and morbidity associated with stroke, myocardial infarction, and heart failure. More studies would be valuable in order to further characterize uncontrolled hypertensives in Canada, particularly with regard to information on non-compliance and specific drug variables.

Bibliography

1. Burt VL, Whelton P, Roccella EJ, Brown C, Cutler JA, Higgins M, Horan MJ, Labarthe D. Prevalence of Hypertension in the US Adult Population: Results from the Third National Health and Nutrition Examination Survey, 1988-1991. Hypertension 1995;25(3):305-13.

2. Joffres MR, Ghadirian P, Fodor GJ, Petrasovits A, Chockalingam A, Hamet P. Awareness, Treatment, and Control of Hypertension in Canada. AJH 1997;10:1097-102.

3. The Sixth Report of the Joint National Committee on the Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. National Institute of Health. 1997; 98-4080. p.1

4. SHEP Cooperative Research Group. Prevention of stroke by antihypertensive drug treatment in older persons with isolated systolic hypertension: final results of the Systolic Hypertension in the Elderly Program (SHEP). Journal of the American Medical Association 1991;265:3255-64.

5. Psaty BM, Smith NL, Siscovick DS, Koepsell TD, Weiss NS, Heckbert SR, Lemaitre RN, Wagner EH, Furberg CD. Health Outcomes Associated With Antihypertensive Therapies Used as First-Line Agents: A Systematic Review and Meta-analysis. Journal of the American Medical Association 1997;277(9):739-45.

6. Collins R, Peto R, MacMahon S, Hebert P, Fiebach NH, Eberlein KA, Godwin J, Qizilbash N, Taylor JO, Hennekens CH. Blood pressure, stroke, and coronary heart disease. Part 2, short-term reductions in blood pressure: overview of randomised drug trials in their epidemiological context. Lancet 1990;335:827-38.

7. Hall DW, Ferrario CM, Moore MA, Hall JE, Flack JM, Cooper W, Simmons DJ, Egan BM, Lackland DT, Perry M, et al. Hypertension-Related Morbidity and Mortality in the Southeastern United States. American Journal of Medical Sciences 1997;313(4):195-209.

8. Colhoun HM, Dong W, Poulter NR. Blood pressure screening, management and control in England: results from the health survey for England 1994. Journal of Hypertension 1998;16:747-52.

9. Smith WCS, Lee AJ, Crombie IK, Tunstall-Pedoe H. Control of blood pressure in Scotland: the rule of halves. British Medical Journal 1990;300:981-3.

10. Mulrow PJ. Detection and Control of Hypertension in the population: The United States Experience. AJH 1998;11:744-6.

11. Klungel Oh, de Boer A, Paes AH, Seidell JC, Nagelkerke NJ, Bakker A. Undertreatment of Hypertension in a population-based study in the Netherlands. Journal of Hypertension 1998;16:1371-8.

12. Di Bari M, Salti F, Nardi M, Pahor M, De Fusca C, Tonon E, Ungar A, Pini R, Masotti G, Marchionni N. Undertreatment of Hypertension in community-dwelling older adults: a drug-utilization study in Dicomano, Italy. Journal of Hypertension 1999;17:1633-40.

13. Chatellier G, Menard J, Devries C, Plouin P, Degoulet P, Corvol P. Blood Pressure Control in a Hypertension clinic. Journal of Hypertension 1987;5(Supplemental 5):s547-9.

14. Joshi PP, Salker RG, Heller RF. Determinants of Poor Blood Pressure control in urban hypertensives of central India. Journal of human Hypertension 1996;10:299-303.

15. Barnett AH. Diabetes and Hypertension. British Medical Bulletin 1994;50(2):397-407.

16. Hypertension Detection and Follow-up Program Cooperative Group. Five-Year Findings of the Hypertension Detection and Follow-up Program: III. Reduction in Stroke Incidence Among Persons With High Blood Pressure. Journal of the American Medical Association 1982;247(5):633-8.

17. Kannel WB. Blood Pressure as a Cardiovascular Risk Factor. Journal of the American Medical Association 1996;275(20):1571-6.

18. Vertes V, Tobias L, and Galvin S. Historical Reflections on Hypertension. Primary Care 1991;18(3):471-81.

19. Stamler J. Blood pressure and high blood pressure: aspects of risk. Hypertension 1991;18(supplement):I-95-7.

20. Feldman RD, Campbell NRC, Larochelle P, Bolli P, Burgess ED, and Carruthers SG. Canadian recommendations for the mangement of hypertension. CMAJ 1999;161(Supplement 12):1-17.

21. Guidelines Subcommittee. 1999 World Health Organization - International Society of Hypertension Guidelines for the management of hypertension. Journal of Hypertension 1999;17151-83.

22. Mancia G, Sega R, Milesi C, Cesana G, Zanchetti A. Blood-pressure control in the hypertensive population. Lancet 1997;349:454-7.

23. Glen SK, Elliot HL, Curzio JL, Lees KR, and Reid JL. White-coat hypertension as a cause of cardiovascular dysfunction. Lancet 1996;348654-7.

24. Modan M, Almog S, Fuchs Z, Chetrit A, Lusky A, Halkin H. Obesity, Glucose Intolerance, Hyperinsulinemia, and Response to Antihypertensive Drugs. Hypertension 1991;17(4):565-73.

25. Hypertension detection and Follow-up Program Cooperative Group: Hypertension Detection and Follow-up Program. Preventative Medicine 1976;5:207-15.

26. The 1984 Report of the Joint National Committee on Detection, Evaluation and Treatment of High Blood Pressure. Journal of the Louisiana State Medical Association 1984;138(7):51-69.

27. Hamet P, Kalant N, Ross SA, Wilson TW, Leenen FH, Haynes BR. Recommendations from the Canadian Hypertension Society Consensus Conference on Hypertension and Diabetes. Canadian Medical association journal 1988;139:1059-62.

28. Fahey TP, Peters TJ. What constitutes controlled hypertension? Patient based comparison of hypertension guidelines. British Medical Journal 1996;313:93-6.

29. The Trials of Hypertension Prevention Collaborative Research Group. The Effects of Nonpharmacologic Interventions on Blood Pressure of Persons With High Normal levels: Results of the Trials of Hypertension Prevention, Phase I. Journal of the American Medical Association 1992;267(9):1213-20.

30. Beilin LJ. Non-pharmacological management of hypertension: optimal strategies for reducing cardiovascular risk. Journal of Hypertension 1994;12(supplemental 10):S71-81.

31. Houston Miller N, Hill M, Kottke T, Ockene IS. The Multilevel Compliance Challenge: Recommendations for a Call to Action. A Statement for Healthcare Professionals. Circulation 1997;95:1085-90.

32. The Hypertension Prevention Trial Research Group. The Hypertension Prevention Trial: Three-Year Effects of Dietary Changes on Blood Pressure. Achives of Internal Medicine 1990;150:153-62.

33. Perez-Stable EJ. Primary Care Teaching Module: Treatment of Hypertension. Forthcoming

34. Ahluwalia JS, McNagny SE, Rask KJ. Correlates of Controlled Hypertension in Indigent, Inner-City Hypertensive Patients. Journal of General Internal Medicine 1997;12:7-14.

35. Stamler R, Stamler J, Gosch FC, Civinelli J, Fishman J, Mckeever P, Mcdonald A, Dyer AR. Primary Prevention of Hypertension by Nutritional-Hygienic Means: Final Report of a Randomized, Control Trial. Journal of the American Medical Association 1989;262(13):1801-7.

36. Setaro JF, Black HR. Refractory Hypertension. The New England Journal of Medicine 1992;327(8):543-7.

37. McAlister FA, Lewanczuk RZ, Teo KK. Resistant Hypertension: An overview. Canadian Journal of Cardiology 1996;12(9):822-8.

38. Materson BJ, Reda DJ, and Cushman WC. Department of Veterans Affairs Cooperative Study Group on Antihypertensive Agents: Single drug therapy for hypertension in men: a comparison of six antihypertensive agents. NEJM 1993;328914-21.

39. Ruilope LM. The hidden truth: what do the clinical trials really tell us about BP control. Journal of human Hypertension 1995;9(Supplement):S3-7.

40. Hansson L, Zanchetti A. The Hypertension Optimal Treatment (HOT) Study - Patient characteristics: randomization risk profiles, and early blood pressure results. Blood Pressure 1994;3:322-7.

41. Stockwell DH, Madhavan S, Cohen H, Gibson G, Alderman MH. The Determinants of Hypertension Awareness, Treatment, and Control in an Insured Population. American Journal of Public Health 1994;84(11):1768-74.

42. Joffres MR, Moulton D. A History of Hypertension. Linacre's 1999;13-7.

43. Hosie J, Wiklund I. Managing hypertension in general practice: can we do better? Journal of human Hypertension 1995;9(supplement):s15-8.

44. Menard J, Chatellier G. Limiting factors in the control of BP: why is there a gap between theory and practice? Journal of human Hypertension 1995;9(Supplemental):S19-23.

45. Oparil S, Calhoun DA. Managing the Patient with Hard-to-Control Hypertension. American Family Physician 1998;57(5):1007-14.

46. Yakovlevitch M, Black HR. Resistant Hypertension in a Tertiary Care Clinic. Archives of Internal Medicine 1991;151:1786-92.

47. Ballard DJ, Strogatz DS, Wagner EH, Siscovick DS, James SA, Kleinbaum DG, Williams CA, Cutchin LM, Ibrahim MA. The Edgecombe County High blood Pressure Control Program: The Process of Medical Care and Blood Pressure Control. American Journal of Preventive Medicine 1986;2(5):278-84.

48. Ballard DJ, Strogatz DS, Wagner EH, Siscovick DS, Sherman JA, Kleinbaum DG, Cutchin LM, Ibrahim MA. Hypertension Control in a Rural Southern Community: Medical Care Process and Dropping Out. American Journal of Preventive Medicine 1988;4(3):133-9.

49. Berlowitz DR, Ash AS, Hickey EC, Friedman RH, Glickman M, Kader B, Moskowitz MA. Inadequate Management of Blood Pressure in a Hypertensive Population. New England Journal of Medicine 1998;339(27):1957-63.

50. Shea S, Misra D, Ehrlich MH, Field L, Francis CK. Correlates of Nonadherence to Hypertension Treatment in an Inner-City Minority Population. American Journal of Public Health 1992;82(12):1607-12.

51. Winickoff RN, Murphy PK. The Persistent Problem of Poor Blood Pressure Control. Archives of Internal Medicine 1987;147:1393-6.

52. Ruoff GE. The Impact of Non-steroidal Anti-inflammatory Drugs on Hypertension: Alternative Analgesics for Patients at Risk. Clinical Therapeutics 1998;20(3):376-87.

53. McClellan WM, Hall DW, Brogan D, Miles C, Wilber JA. Continuity of Care in Hypertension: An Important Correlate of Blood Pressure control Among Aware Hypertensives. Archives of Internal Medicine 1988;148:525-8.

54. McNagny SE, Ahluwalia JS, Clark SW, Resnicow KA. Cigarette Smoking and Severe Uncontrolled Hypertension in Inner-city African Americans. The American Journal of Medicine 1997;103:121-7.

55. Degoulet P, Menard J, Vu H, Golmard J, Devries C, Chatellier G, Plouin P. Factors predictive of attendance at clinic and blood pressure control in hypertensive patients. British Medical Journal 1983;287:88-93.

56. Schultz JF, Sheps SG. Management of Patients with Hypertension: A Hypertension Clinic Model. Mayo clinic Proceedings 1994;69:997-9.

57. Trials of Hypertension Prevention Collaboration Research Group. Effects of weight loss and sodium reduction intervention on blood pressure and hypertension incidence in overweight people with high normal blood pressure: the Trials of Hypertension Prevention, phase II. Archives of Internal Medicine 1997;157:657-67.

58. Hypertension Detection and Follow-up Program Cooperative Group. Educational Level and 5-Year All-Cause Mortality in the Hypertension Detection and Follow-up Program. Hypertension 1987;9(6):641-6.

59. Thomson GE. Latest Guidelines on the Treatment of High Blood Pressure. Journal of the National Medical Association 1985;77(suppl):7-8.

60. Forman MR, Trowbridge FL, Gentry EM, Marks JS, Hogelin GC. Overweight adults in the United States: the behavioral risk factor surveys. The American Journal of Clinical Nutrition 1986;44:410-6.

61. Isaksson H, Danielsson M, Rosenhamer G, Konarski-Svensson JC, Ostergren J. Characteristics of patients resistant to antihypertensive drug therapy. Journal of Internal Medicine 1991;229:421-6.

62. Wagner EH, Sherman JA, Beresford SA, Strogatz DS, Grimson RC, Kleinbaum DG, Williams CA, Cutchin LM, Ibrahim MA. The Edgecombe County High Blood Pressure Control Program: Correlates of Uncontrolled Hypertension at Baseline. American Journal of Public Health 1984;74(3):237-42.

63. Macdonald MB, Sawatzky JE, Wilson TW, Laing GP. Predicting success in antihypertensive drug therapy: The importance of nondrug variables. Canadian Journal of Cardiology 1991;7(1):19-23.

64. Shea S, Misra D, Ehrlich MH, Field L, Francis CK. Predisposing Factors for Severe, Uncontrolled Hypertension in an Inner-city Minority Population. New England Journal of Medicine 1992;327:776-81.

65. Maclean DR, Petrasovits A, Nargundkar M, Connelly PW, Mcleod E, Edwards A, Hessel P. Canadian Heart Health Surveys: A profile of cardiovascular

risk. Survey methods and analysis. Canadian Medical association journal 1992;146(11):1969-74.

66. Promoting Heart Health in Canada: Linking Research, Policy and Action. The Canadian Heart Health Database 1986-1992. [computer program]. Statistics Canada; 1997; CD ROM. Windows.

67. SPSS for Windows [computer program]. Standard. SPSS; 1996; Statistical software package. Windows.

68. Hosmer DW; Lemeshow S. Cressie NAC, Fisher NI, Iain MJ et al. editors. Applied Logistic Regression. Second ed. John Wiley & Sons, Inc. 2000.

69. Macdonald MB, Sawatzky JE, Wilson TW. Lifestyle Behaviors in Treated Hypertensives as Prediction of Blood Pressure Control. Rehabilitation Nursing 1988;13(2):82-4.

70. Barton SN, Coombs DW, Miller HL, Hughes GH, Cutter G. Comparison of Hypertension Prevalence and Control in 5,237 Rural and Urban Alabama Residents. Southern Medical Journal 1987;80(10):1220-3.

71. van Russum CT, Shipley MJ, van de Mheen H, Grobbee DE, and Marmot MG. Employment grade differences in casue specific mortality. A 25 year follow up of civil servants from the first Whitehall study. Journal of Epidemiology & Community Health 2000;54(3):178-84.

72. Brunner E, Shipley MJ, Blane D, Smith GD, and Marmot MG. When does cardiovascular risk start? Past and present socioeconomic circumstances and risk factors in adulthood. Journal of Epidemiology & Community Health 1999;53(12):757-64.

73. Morisky DE, Green LW, Levine DM. Concurrent and predictive validity of a self-reported measure of medication adherence. Medical Care 1986;24:67-74.

74. Borghi C, Prandin MG, Costa FV, Bacchelli S, Degli Esposti D, Ambrosioni E. Use of Statisn and Blood Pressure Control in Treated Hypertensive Patients with Hypercholesterolemia. Journal of Cardiovascular Pharmacology 2000;35:549-55.