Canadian Journal of Cardiology 27 (2011) 159–166

Clinical Research

Estimating the Benefits of Patient and Physician Adherence to Cardiovascular Prevention Guidelines: The MyHealthCheckup Survey

Steven Grover, MD, MPA, FRCPC,[a,b,c,d] Louis Coupal, MSc,[a,b] Mohammed Kouache, MSc,[a,b] Ilka Lowensteyn, PhD,[a,b] Sylvie Marchand, RN,[a,b] and Norman Campbell, MD, FRCPC[e]

[a] *Centre for the Analysis of Cost-Effective Care, McGill Cardiovascular Health Improvement Program, Montreal, Québec, Canada*

[b] *Division of Clinical Epidemiology, Department of Medicine, McGill University Health Centre, Montreal, Québec, Canada*

[c] *Division of Internal Medicine, Department of Medicine, McGill University Health Centre, Montreal, Québec, Canada*

[d] *Faculty of Medicine, McGill University, Montreal, Québec, Montreal, Québec, Canada*

[e] *Department of Medicine, Community Health Sciences and Pharmacology, Libin Cardiovascular Institute of Alberta, University of Calgary, Calgary, Alberta, Canada*

ABSTRACT

Background: The management of cardiovascular risk factors such as hypertension and dyslipidemia is poorly described in many communities, and the benefits associated with tighter control remain unknown. We used data from the 2007 MyHealthCheckup survey to document the treatment gaps and estimated the potential benefits of better adherence to recommended guidelines.

Methods: Cardiovascular risk factors, lifestyle habits, and prescribed medications were evaluated among Canadian adults recruited primarily in pharmacies. The Cardiovascular Life Expectancy Model was used to estimate the potential benefits of optimally treating hypertension or dyslipidemia (defined as not smoking, regular physical activity, an acceptable body weight, and maximal medication as needed).

Results: Among 2674 screened individuals, 1266 (47%) were receiving pharmacotherapy for either dyslipidemia or hypertension, including 772 (61%) and 656 (63%), respectively, who remained above treatment targets. Among those above lipid or blood pressure targets, 27% and 22%, respectively, were optimally treated. The average increased life expectancy or life-years gained associated with making appropriate lifestyle changes included 2.2 to 4.7 years from smoking cessation, 0.7 to 1.1 years from regular exercise, and 0.4 to 0.7 years from weight reduction. The life-years gained following better risk factor

RÉSUMÉ

Introduction : La gestion des facteurs de risque cardiovasculaire comme l'hypertension et la dyslipidémie est décrite de façon insatisfaisante dans plusieurs communautés, et les bénéfices associés à un contrôle plus strict demeurent inconnus. Nous avons utilisé les données de 2007 de l'enquête MonBilanSanté pour documenter les écarts de traitement et nous avons évalué les bénéfices potentiels d'une meilleure adhésion aux lignes directrices recommandées.

Méthodes : Les facteurs de risque cardiovasculaire, les habitudes de vie et la médication prescrite étaient évalués chez des adultes canadiens recrutés essentiellement dans les pharmacies. Le *Cardiovascular Life Expectancy Model* était utilisé pour évaluer les bénéfices potentiels d'un traitement optimal de l'hypertension ou de la dyslipidémie (défini par l'abstinence de fumer, l'activité physique régulière, un poids corporel acceptable et une médication maximale au besoin).

Résultats : Parmi les 2674 sujets sélectionnés, 1266 (47 %) recevaient une pharmacothérapie pour une dyslipidémie ou une hypertension, soit 772 (61 %) et 656 (63 %) respectivement, ce qui demeure supérieur aux objectifs de traitement. Chez ceux dont les objectifs lipidiques et de pression artérielle sont supérieurs, 27 % et 22 % respectivement étaient traités de façon optimale. L'augmentation moyenne de l'espérance de

Although cardiovascular disease remains the leading cause of death among Canadians and is associated with substantial health care costs, modifiable risk factors remain untreated or undertreated among many individuals.[1-10] Suboptimal risk factor management is also widespread in the United States and Europe.[11,12] To what extent this trend is due to poor physician adherence to national treatment guidelines or poor patient compliance with physician recommendations is unknown.

In 2006, the MyHealthCheckup (MHC) survey was initiated to identify current lifestyle habits and prescribed medical therapy to prevent cardiovascular disease (CVD) among Canadian adults. As of the end of 2007, nearly 2800 individuals

Received for publication June 11, 2009. Accepted October 12, 2009.

Corresponding author: Dr Steven A. Grover, Research Institute, McGill University Health Centre, 687 Pine West, V Building, V2.07, Montreal, Québec H3A 1A1, Canada.

E-mail: steven.grover@mcgill.ca

See page 165 for disclosure information.

0828-282X/$ – see front matter
doi:10.1016/j.cjca.2011.01.007

treatment included maximal pharmacotherapy for elevated blood pressure (0.6-0.8), low-density lipoprotein cholesterol (0.5-0.6), and the ratio of total cholesterol to high-density lipoprotein cholesterol (0.3-0.4). Years of life free of cardiovascular disease would be similarly increased.

Conclusions: Better treatment of cardiovascular risk factors could result in a substantial reduction in morbidity and mortality among Canadians. Given current physician prescribing and patient habits, lifestyle modification should be considered a priority before additional medications are prescribed.

vie ou le gain d'années de vie associées à des changements appropriés du style de vie incluait l'abandon du tabac (2,2 – 4,7), l'exercice régulier (0,7 – 1,1) et la perte de poids (0,4 – 0,7). Le gain d'années de vie augmente après un meilleur traitement du facteur de risque a inclus une pharmacothérapie maximale pour une pression artérielle élevée (0,6 – 0,8), un cholestérol LDL (0,5 – 0,6) et un ratio CT/C-HDL (0,3 – 0,4). Les années de vie sans maladie cardiovasculaire augmenteraient de façon similaire.

Conclusions : Un meilleur traitement des facteurs de risque cardiovasculaire aboutirait à une réduction substantielle de la morbidité et de la mortalité chez les Canadiens. Compte tenu des ordonnances médicales actuelles et des habitudes de vie des patients, une modification du style de vie devrait être prioritairement envisagée avant l'ajout d'une médication.

agreed to participate in the survey, which included on-site measurement of their blood lipids and blood pressure. These data can therefore provide insights into both patient and physician adherence to current treatment and prevention guidelines.

The objective of the present study was to identify the therapeutic shortcomings currently observed among Canadians treated for dyslipidemia or hypertension and to estimate the impact of bridging these gaps, given the available options. Accordingly, we used the MHC survey and the Cardiovascular Life Expectancy Model, a previously validated cardiovascular disease simulation model, to estimate the potential benefits associated with smoking cessation and optimally controlling dyslipidemia and hypertension through lifestyle modification and medical therapy.

Methods

The potential benefits of optimally treating hypertension or dyslipidemia among Canadians were estimated from the results of published clinical trials, current Canadian treatment guidelines, drug use and risk factor data from the MHC survey, and a previously published Markov model to calculate the increased life expectancy and decreased morbidity associated with optimally treating risk factors.[13-16] The analyses presented herein focus specifically on individuals who were already being treated with prescribed medications for hypertension or dyslipidemia.

The MHC survey

The MHC survey is a cross-sectional survey to evaluate adults with cardiometabolic conditions and associated risk factors. The study protocol underwent ethics approval. Adults, aged 30 years and older, were screened at pharmacies and in the workplace across Canada. The original eligibility criteria included all individuals with cardiovascular disease or diabetes, as well as women aged 50 years and older and men aged 40 years and older with at least 1 of the following risk factors: hypertension, dyslipidemia, tobacco smoking, obesity, or sedentary lifestyle. However, during the second year of recruitment, individuals with a strong family history of diabetes or heart disease were also included in the study. This resulted in younger participants' being enrolled. After signing informed consent, each participant filled out a brief questionnaire and then had the following measured: height, weight, abdominal circumference, and blood pressure. Blood pressure was measured twice in the sitting position, with the Life-Source UA-767 Plus (A&D Engineering, Inc., San Jose, CA, USA) with the appropriate sized arm cuff, after a wait of approximately 5 minutes. The lower of the 2 readings was used for this study. Capillary blood by finger prick was then drawn to measure nonfasting glucose, total cholesterol (TC), and high-density lipoprotein cholesterol (HDL-C) with the Cholestech LDX desktop analyzer (Cholestech Corporation, Hayward, CA, USA). Adequate physical activity was defined by an affirmative response to the following: "Do you do vigorous exercise for at least 90 minutes per week or moderate physical activity for at least 3 hours per week?"[17] A detailed survey of prescribed medications was provided by each participant and confirmed or corrected by the community pharmacist (except in the 2 workplace screenings).

A personalized cardiovascular risk profile was then provided to the participant based on the Cardiovascular Life Expectancy Model.[16] The profile included the individual's 10-year risk of CVD and the potential benefits of modifying treatable risk factors. Each participant's risk profile was explained to the participant, and an individualized action plan was discussed.

Determination of blood low-density lipoprotein cholesterol (LDL-C) requires a fasting lipid profile in which triglycerides can be measured. In a community survey based in pharmacies, it is impossible to efficiently collect fasting lipid data over the course of the day. We therefore estimated the LDL-C level from nonfasting blood tests based on data from the National Health and Nutrition Examination Study III.[18] Data for US adults were used to develop a multivariate regression equation in which the predicted LDL-C value is a function of the measured TC and HDL-C and the presence or absence of diabetes. The final equation was: predicted LDL-C (mmol/L) = $-0.3516 + (\text{TC} \cdot 0.8612) - (\text{HDL-C} \cdot 0.6652) - (\text{diabetes}\{0 \text{ if absent or } 1 \text{ if present}\} \cdot 0.1468)$.

This regression equation was then externally validated on data from the Canadian Heart Health Surveys (n = 18,347), in which LDL-C values had also been calculated from a fasting lipid profile and the Friedwald equation, in which LDL-C is a function of TC, HDL-C, and triglycerides.[15] The estimated LDL-C value was within 0.5 mmol/L of the Friedwald-calculated LDL-C value 93% of the time.

For those who had not achieved treatment targets (defined below), we defined optimal treatment as not smoking, regular physical activity (defined above), an acceptable body weight (body mass index ≤ 27 kg/m^2), and maximal daily medication

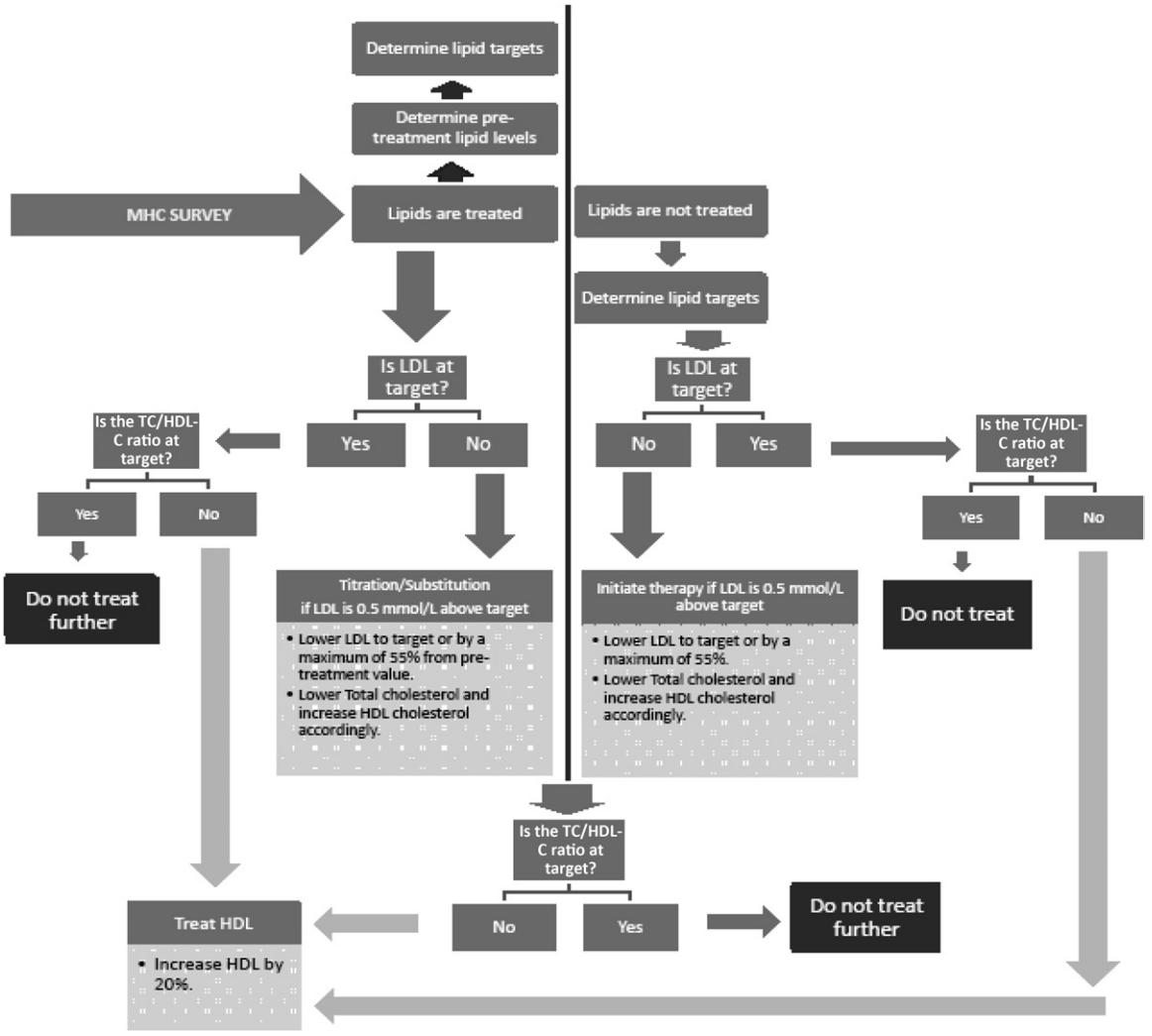

Figure 1. Expected treatment of blood lipid levels based on Canadian guidelines and data collected from the MyHealthCheckup survey. HDL, high-density lipoprotein; LDL, low-density lipoprotein; MHC, MyHealthCheckup survey; TC/HDL-C Ratio, ratio of total cholesterol to HDL cholesterol.

(atorvastatin 80 mg or rousuvastatin 40 mg, or 2 or more lipid-lowering drugs, and 3 or more antihypertensive drugs).

Guidelines for lipid treatment

The 2006 Canadian Working Group guidelines for the management of dyslipidemia recommend target levels including LDL-C <2.0 mmol/L and a TC/HDL-C ratio <4 for people at high risk for CVD, LDL-C <3.5 mmol/L and a TC/HDL-C ratio <5 for people at moderate risk, and LDL-C <5.0 mmol/L and a TC/HDL-C ratio <6 for people at low risk.[14]

For individuals without diabetes or CVD, the Framingham coronary risk equations were used to estimate the 10-year risk of disease in order to identify target lipid levels. If an individual was already receiving lipid therapy, we back calculated the individual's untreated lipid values on the basis of his or her current drug treatment and published efficacy data for statins, fibrates, resins, and niacin (Fig. 1).

We assumed that there was substantial room for improvement if an individual's LDL-C was 0.5 mmol/L above target. This conservative assumption also recognizes the margin of error surrounding LDL levels estimated from nonfasting blood samples as described above. The benefits of regular exercise were based on a meta-analysis of controlled trials demonstrating average changes in LDL-C (−5%), HDL-C (+4.6%), and systolic and diastolic blood pressure (−7.4/−5.8 mm Hg).[19-21] The potential benefits of weight reduction (−3.4 kg) were based on a comparison of the differences in blood pressure (−5.4/−3.7 mm Hg) and HDL-C (+4.9 mg/dL) observed after 12 months in participants in the Weight Watchers diet in the A TO Z Weight Loss Study.[22] Medical therapy was assumed to maximally reduce LDL-C (−55%) below pretreatment values. For each 1% decrease in LDL-C, changes in TC (−.71%) and HDL-C (+.14%) were imputed on the basis of the results of the Scandinavian Simvastatin Survival Study.[23] For example, a 25% decrease in TC and a 5% increase HDL-C would be associated with a 35% decrease in LDL-C. Once LDL-C reached recommended targets or was maximally treated, we assumed that the TC/HDL-C ratio would be treated as a secondary target only if it was 0.5 units above recommended levels, which could be increased a maximum of 20%, based on the results of adding extended-release niacin to

Table 1. Clinical characteristics (means or percentages) of MHC patients either on lipid or blood pressure medication stratified by baseline cardiovascular risk status*

Patient characteristics	High risk			Medium risk	Low risk	All
	CVD	Diabetes only	Neither			
N	313	218	92	173	470	1266
Age	67	64	71	67	61	65
Male (%)	66%	44%	91%	61%	14%	44%
Body mass index (kg/m2)	29	31	29	28	28	29
Body mass index > 27 kg/m^2 (%)	60%	70%	62%	53%	55%	59%
Waist circumference (cm)	101	104	105	97	94	99
Exercise less than 720 METS/week (%)	42%	55%	39%	42%	46%	46%
Total cholesterol (mmol/L)	4.17	4.57	4.93	5.30	5.26	5.03
HDL-C (mmol/L)	1.07	1.14	0.88	1.13	1.38	1.25
LDL-cholesterol (mmol/L)	2.48	2.68	3.31	3.46	3.26	3.12
TC/HDL-C ratio	4.3	4.38	5.97	4.99	4.16	4.42
Blood pressure	133/73	139/76	148/80	142/78	132/77	136/76
Currently smoking (%)	14%	11%	15%	10%	9%	11%
Taking drugs for hyperlipidemia (%)	84%	69%	40%	50%	50%	61%
Taking drugs for high blood pressure (%)	91%	78%	89%	81%	76%	82%

CVD, cardiovascular disease; HDL-C, high-density lipoprotein-cholesterol; LDL, low-density lipoprotein; METS, metabolic equivalent of task; MHC, MyHealthCheckup survey; TC, total cholesterol.

*The calculated 10-year Framingham Risk is >20% for high-risk individuals without CVD or diabetes, 10% to 20% for moderate-risk individuals, and <10% for low-risk individuals.

statins in the Arterial Biology for the Investigation of the Treatment Effects of Reducing Cholesterol 2 study.[24]

Guidelines for hypertension management

During the study, the 2007 Canadian Hypertension Education Program recommended blood pressure levels <140/90 mm Hg for most individuals and below 130/90 mm Hg for those with diabetes.[13] Assuming some daily variation in an individual's blood pressure readings, we evaluated the benefits of further treatment only among those whose blood pressure was at least 5 mm Hg above these targets. Based on the published analysis by Law et al,[25] we assumed that blood pressure could be reduced to prescribed targets or up to a maximum change of −20/−10 mm Hg below pretreatment levels by the use of 3 medications. Individuals already receiving 1 blood pressure medication could reduce their pressure an additional −13.2/−7.0 mm Hg, while those on 2 medications could obtain an additional −6.6/−3.4 mm Hg drop.

Cardiovascular Disease Life Expectancy Model

The Cardiovascular Disease Life Expectancy Model was used to estimate the annual probability of CVD events on the basis of logistic regression equations developed from the Lipid Research Clinic Follow-up cohort. This Markov model has been described in detail previously[16] and shown to reasonably estimate events in 9 clinical trials of dyslipidemia or hypertension and in the participants with diabetes in the Scandinavian Simvastatin Survival Study, as well as the life expectancy of US and Canadian adults.[23,26-29]

Briefly, individual patients are entered into the model with specified levels of risk factors. Each year, patients can die of either coronary heart disease, cerebrovascular disease, or other causes. Surviving patients age 1 year and reenter the model for the following year. To estimate the impact of modifying 1 or more risk factors, the individual is reentered into the model after the expected changes in blood lipids, blood pressure, or smoking status. Treatment benefits are calculated as life-years gained (LYG) or years free of cardiovascular disease (YFD).

Individuals in the MHC data set were stratified by cardiovascular risk status as per current treatment guidelines.[14] The potential benefits associated with maximal blood pressure or blood lipid changes or smoking cessation were then estimated. For lipid and blood pressure therapy, we assumed a 1-year delay before benefits would be realized, which is consistent with the observed results of placebo-controlled clinical trials. The benefits of smoking cessation were assumed to occur after a 4-year delay.[30]

Results

Between March 2006 and November 2007, we completed health screenings at 48 pharmacies and 2 workplace settings across Canada and enrolled 2674 participants in regions including the Maritimes (273), Québec (1000), Ontario (799), and Western Canada (602). Included in the present analyses are 1266 individuals, aged between 30 and 79 years, who were taking prescribed medication for hypertension or dyslipidemia. Among these participants (Table 1), medical treatments for hypertension (82%) and dyslipidemia (61%) were common. Unhealthy lifestyles were also common, including excess body weight (59%), cigarette smoking (11%), and inadequate regular physical activity (46%).

Among 1037 hypertensive individuals on treatment, 37% were at least 5 mm Hg above systolic or diastolic targets (Table 2). Poor blood pressure control was particularly common (65%) among individuals with diabetes. Among those with uncontrolled hypertension, only 3% were optimally treated, defined as being nonsmokers, physically active, not overweight, and taking at least 3 antihypertensive medications to manage their poorly controlled blood pressure. Suboptimal patient compliance included excess body weight (64%), a sedentary lifestyle (52%), and cigarette smoking (10%). Submaximal medical therapy, despite poorly controlled hypertension, was common as 50% were prescribed 1 antihypertensive drug, 33% were prescribed 2 drugs, and only 17% were taking 3 or more drugs.

Table 2. Characteristics of individuals not adequately treated

	High risk					
	CVD	Diabetes only	Neither	Medium risk	Low risk	All
Not at LDL target	92	63	25	29	4	213
Normalized statin dose (mg/day)	17	14	15	13	3	16
1 Drug	83 (90%)	60 (95%)	23 (92%)	29 (100%)	4 (100%)	199 (93%)
Maximal pharmacotherapy	9 (10%)	3 (5%)	2 (8%)	0 (0%)	0 (0%)	14 (7%)
Smokes cigarettes	13 (14%)	10 (16%)	5 (20%)	7 (24%)	1 (25%)	36 (17%)
Exercise < 720 METS per week	40 (43%)	41 (65%)	8 (32%)	13 (45%)	2 (50%)	104 (49%)
BMI > 27 kg/m^2	59 (64%)	48 (76%)	17 (68%)	11 (38%)	2 (50%)	137 (64%)
Optimally managed	1 (1%)	0 (0%)	1 (4%)	0 (0%)	0 (0%)	2 (1%)
Not at TC/HDL-C ratio target	47	23	11	18	10	109
Normalized statin dose (mg/day)	20	15	14	12	11	16
1 Drug	37 (63%)	20 (42%)	9 (53%)	18 (100%)	10 (100%)	94 (69%)
Maximal pharmacotherapy	10 (21%)	3 (13%)	2 (18%)	0 (0%)	0 (0%)	15 (14%)
Smokes cigarettes	7 (15%)	5 (22%)	2 (18%)	4 (22%)	2 (20%)	20 (18%)
Exercise < 720 METS per week	24 (51%)	14 (61%)	5 (45%)	10 (56%)	3 (30%)	56 (51%)
BMI > 27 kg/m^2	36 (77%)	20 (87%)	8 (73%)	7 (39%)	6 (60%)	77 (71%)
Optimally managed	1 (2%)	0 (0%)	1 (9%)	0 (0%)	0 (0%)	2 (2%)
Not at blood pressure targets	88	112	41	55	85	381
1 Drug	30 (34%)	55 (49%)	17 (41%)	35 (64%)	55 (65%)	192 (50%)
2 Drugs	30 (34%)	38 (34%)	17 (41%)	15 (27%)	25 (29%)	125 (33%)
Maximal pharmacotherapy	28 (32%)	19 (17%)	7 (17%)	5 (9%)	5 (6%)	64 (17%)
Smokes cigarettes	11 (13%)	9 (8%)	6 (15%)	5 (9%)	8 (9%)	39 (10%)
Exercise < 720 METS per week	46 (52%)	62 (55%)	23 (56%)	30 (55%)	36 (42%)	197 (52%)
BMI > 27 kg/m^2	57 (65%)	82 (73%)	24 (59%)	29 (53%)	50 (59%)	242 (64%)
Optimally managed	5 (6%)	3 (3%)	2 (5%)	0 (0%)	1 (1%)	11 (3%)

For subjects at lipid target, nonsmokers with a BMI less than 27 kg/m^2 and exercising more than 720 METS per week are considered optimally managed. For subjects not at target, optimal management also includes the use of 2 or more lipid drugs (maximal pharmacotherapy). For subjects at blood pressure target, nonsmokers with a BMI less than 27 kg/m^2 and exercising more than 720 METS per week are considered optimally managed. For subjects not at target, optimal management also includes the use of 3 or more blood pressure drugs (maximal pharmacotherapy).

BMI, body mass index; LDL, low-density lipoprotein; HDL-C, high-density lipoprotein-cholesterol; METS, metabolic equivalent of task; TC, total cholesterol.

Among 772 individuals treated for dyslipidemia, 28% were at least 0.5 mmol/L above both LDL-C targets, and 14% were at least 0.5 units above the TC/HDL-C ratio target. Low-risk individuals were most likely to be at lipid targets (95%), whereas high-risk individuals without diabetes or cardiovascular disease were least likely (27%). Optimal management was rare for those not at LDL-C targets (1%) or TC/HDL-C ratio targets (2%). Poor lifestyle habits, including excess weight (64%), infrequent exercise (49%), and smoking (17%), were common among the majority of individuals whose LDL-C was poorly controlled. The same was true for those with an elevated TC/HDL-C ratio. Submaximal pharmacotherapy was also common among those with elevated LDL-C (93%) or TC/HDL-C ratio (86%).

The potential benefits of better compliance with recommended interventions are presented in Table 3. Smoking cessation is paramount as the potential benefits are particularly large, averaging 2.2 to 5.0 LYG and 1.8 to 4.8 YFD. Regular exercise for sedentary individuals would be associated with 0.7 to 1.1 LYG and 1.0 to 1.9 YFD, while modest weight reduction would increase life expectancy by 0.4 to 0.7 years and add 0.7 to 1.6 YFD. Gains from combined exercise and weight loss are even better.

More intensive control of blood pressure with medication would result in 0.6 to 0.8 LYG and 0.7 to 1.3 YFD. Additional treatment of elevated LDL-C would result in 0.5 to 0.6 LYG and 1.3 to 1.7 YFD. After maximally treating LDL-C with statins, 32% of individuals would still have a TC/HDL-C ratio at least 0.5 units above target. An additional 20% increase in HDL-C would result in an additional 0.3 to 0.4 LYG and 0.8 to 1.5 YFD.

Comparing optimal risk factor management in primary vs secondary prevention, the potential increases in life expectancy are similar. Moreover, individuals without diagnosed cardiovascular disease may also enjoy additional benefits associated with delaying the onset of disease, as summarized by the LYG in Table 3. Finally, lifestyle interventions and prescribed medication appear particularly important among low-risk individuals, in whom small reductions in risk played out over many years can eventually become substantial.

Discussion

These results demonstrate that there remains significant room for improvement in risk factor management by both patients and their physicians. Better control of blood pressure or blood lipids with maximal medical therapy would add 0.3 to 0.8 years to life expectancy. Given current lifestyle habits of patients already on drug therapy and current prescribing patterns, the potential benefits associated with lifestyle modification may be larger than those associated with additional medication. Smoking cessation is of primary importance. The risk of cardiovascular death is increased 2- to 3-fold among those who smoke.[16] Accordingly, no other preventive intervention appears to increase a smoker's life expectancy more than smoking cessation (2.2-5.0 LYG). Among individuals medically treated for hypertension or dyslipidemia, the high prevalence of sedentary behaviour and excess body weight, identify exercise

Table 3. Benefits associated with treating subjects on medication but not at target

Risk status (life expectancy)	Intervention	LDL		Tota-to-/HDL ratio		Blood pressure	
		LYG	YFD	LYG	YFD	LYG	YFD
High risk cardiovascular disease (16 years)	Diet	0.4	NC	0.4	NC	0.5	NC
	Exercise	0.7	NC	0.8	NC	0.8	NC
	Diet and exercise	0.8	NC	0.8	NC	0.8	NC
	Smoking	3.6	NC	3.5	NC	3.7	NC
	Drugs	0.5	NC	0.3	NC	0.6	NC
High risk diabetes without cardiovascular disease (16 years)	Diet	0.6	1.0	0.6	0.8	0.5	0.8
	Exercise	1.0	1.3	1.0	1.1	0.9	1.1
	Diet and exercise	1.2	1.7	1.1	1.3	1.0	1.4
	Smoking	3.7	1.8	3.9	1.3	2.2	0.3
	Drugs	0.6	1.6	0.4	0.8	0.8	0.8
High risk 10-year risk ≥ 20% (12 years)	Diet	0.4	0.7	0.4	0.7	0.5	0.7
	Exercise	0.7	1.0	0.8	1.0	0.8	1.0
	Diet and exercise	0.6	0.9	0.6	0.9	0.9	1.2
	Smoking	3.8	2.0	4.4	2.3	2.7	1.4
	Drugs	0.5	1.3	0.4	0.9	0.6	0.7
Medium risk 10-year risk between 10% and 20% (17 years)	Diet	0.5	1.0	0.5	1.0	0.5	1.0
	Exercise	0.8	1.4	0.9	1.4	0.8	1.4
	Diet and exercise	0.8	1.5	0.9	1.6	0.9	1.6
	Smoking	4.3	4.0	4.0	3.2	3.4	2.7
	Drugs	0.6	1.7	0.3	1.0	0.6	1.0
Low risk 10-year risk < 10 % (23 years)	Diet	0.5	1.2	0.7	1.6	0.5	1.4
	Exercise	0.9	1.7	1.1	1.9	0.8	1.8
	Diet and exercise	1.0	1.9	1.2	2.2	0.9	2.2
	Smoking	4.7	4.8	4.7	5.0	4.6	4.8
	Drugs	0.5	1.6	0.4	1.5	0.6	1.3
All (18 years)	Diet	0.5	0.9	0.5	0.9	0.5	1.0
	Exercise	0.9	1.3	0.9	1.2	0.8	1.3
	Diet and exercise	1.0	1.5	0.9	1.3	0.9	1.5
	Smoking	3.8	2.7	3.9	2.7	3.4	2.5
	Drugs	0.6	1.6	0.3	0.9	0.7	0.9

HDL, high-density lipoprotein; LDL, low-density lipoprotein; LYG, life-years gained; NC, not calculted; YFD, years free of cardiovascular disease.

and weight reduction as important treatment modalities that could add 0.4 to 1.3 years to life expectancy.

There are a number of important limitations in this study, including the focus on individuals already being treated for hypertension or dyslipidemia. The decision to restrict the analysis to only treated individuals was based on the assumption that a pharmacy screening can be used to assemble a representative cohort of adults receiving prescription medications. The generalizability of individuals with risk factors but not on therapy would be more questionable. Comparisons with other Canadian studies described below support this decision. One must also recognize that the estimated benefits presented herein are based on the Cardiovascular Life Expectancy Model, a disease simulation model. Simulation models cannot provide the same level of evidence as results from clinical trials. On the other hand, a trial addressing the treatment gaps discussed in these analyses is unlikely to be forthcoming. Even if such a trial was completed, it would be unlikely to recruit individuals who are a true reflection of the population of interest, given the usual biases in patient sampling. Accordingly, we believe that these results, based on an extensively validated disease simulation model, are reasonable estimates of the potential benefits that could result from bridging the treatment gaps among a representative cohort of Canadian patients who are already receiving treatment of dyslipidemia or hypertension.

The Canadian data provided by the 2006-2007 MHC survey can be compared with the results of other surveys, such as the 2006 CardioMonitor study in the United States and Europe.[11] In the MHC survey, 33% of individuals had blood pressure above 140/90 mm Hg, compared with 35% of US residents and 51% of Europeans. Among those at high risk (known cardiovascular disease, diabetes, or Framingham risk >20%), 56% of the MHC cohort had LDL-C above 2.5 mmol/L, compared with 76% of those from the United States and 70% of those from the United Kingdom. These data are also comparable to those from other Canadian surveys. Among those individuals treated for dyslipidemia in a 2000-2003 Southwestern Ontario survey conducted in physician offices,[31] 47% had LDL-C or a TC/HDL-C ratio above treatment targets, compared with 48% among MHC participants. The success in reaching hypertension treatment targets in the MyHealthCheckup study (63%) was also similar to the results observed in the much larger, randomly sampled Ontario Survey on the Prevalence and Control of Hypertension (65.7%).[32]

The forecast benefits for Canadians treated over their remaining life expectancy are modest compared with similar forecasts by Khan et al[33] (over 30 years) for people in the United States. For the treatment of hypertension, the estimates range from 0.3 to 0.4 LYG vs 0.94 to 1.78 LYG.[33] For dyslipidemia among individuals with known coronary disease, the benefits associated with treating LDL-C to <2 mmol/L were estimated as 2.45 LYG by Kahn et al[33] vs 0.5 years in our analyses. One of the major differences in these projections is that we have estimated the benefits associated with clinically feasible reductions, whereas Khan and colleagues projected the benefits of getting all individuals below treatment targets regardless of whether this goal is actually possible. The forecast benefits are also conservative in a number of other ways. We have assumed that only individuals whose risk factors are sub-

stantially above treatment targets would be treated more aggressively. We have also assumed that lifestyle modification would impact only cardiovascular risk factors, but there are consistent trial data confirming that exercise and weight loss can also reduce the risk of developing diabetes, which is strongly associated with both macrovascular and microvascular complications.[34] Finally, an analysis of the Health Professional Follow-up Study showed that the adoption of healthy lifestyles, even among individuals already taking medication for hypertension or dyslipidemia, was associated with a reduction in coronary events.[35]

We conclude that among individuals being treated for hypertension or dyslipidemia, lifestyle modification should be a top priority. Better physician adherence to treatment guidelines to lower blood pressure, LDL-C, and the TC/HDL-C ratio also appears to be clinically feasible and should reduce the morbidity and mortality associated with cardiovascular disease.

Acknowledgements

The authors gratefully acknowledge the help of Mr Sebastien Morin from Merck Canada for his support in completing this study.

Funding Sources

The data analysis for this investigator-initiated study was supported by a research grant from Merck Canada. The principal investigator had full control over the study design, data collection, data analysis, and manuscript preparation.

Disclosures

Dr Steven Grover, Dr Ilka Lowensteyn, Mr Mohammed Kaouache, Mr Louis Coupal, and Ms Sylvie Marchand have also received research grants from Pfizer, Sanofi Aventis, and AstraZeneca. Dr Grover has received speaker honouraria from Pfizer, Sanofi Aventis, and Merck, and Dr Campbell has received speaker honouraria from Bayer, Sanofi Aventis, Bristol Myers Squibb, Biovail, and Pfizer. In addition, Dr Grover has either been a consultant or participated on an advisory board for AstraZeneca, Sanofi Aventis, Pfizer, and Merck, and Dr Norman Campbell for Pfizer, Servier, Boehringer Ingelheim, Novartis, and Schering-Plough.

References

1. Grover S, Coupal L, Lowensteyn I. Preventing cardiovascular disease among Canadians: is the treatment of hypertension or dyslipidemia cost-effective? Can J Cardiol 2008;24:891-8.
2. Grover SA, Lowensteyn I, Joseph L, et al. Discussing coronary risk with patients to improve blood pressure treatment: secondary results from the CHECK-UP study. J Gen Intern Med 2009;24:33-9.
3. Grover SA, Lowensteyn I, Joseph L, et al. Patient knowledge of coronary risk profile improves the effectiveness of dyslipidemia therapy: the CHECK-UP study: a randomized controlled trial. Arch Intern Med 2007; 167:2296-303.
4. Grima DT, Leiter LA, Goodman SG, et al. How many cardiovascular events can be prevented with optimal management of high-risk Canadians? Can J Cardiol 2008;24:363-8.
5. Austin PC, Mamdani MM, Juurlink DN, et al. Missed opportunities in the secondary prevention of myocardial infarction: an assessment of the effects of statin underprescribing on mortality. Am Heart J 2006; 151:969-75.
6. Yan AT, Yan RT, Tan M, et al. Contemporary management of dyslipidemia in high-risk patients: targets still not met. Am J Med 2006;119: 676-83.
7. Joffres MR, Kamath TV, Williams GR, et al. Impact of guidelines on health care use for the management of dyslipidemia in two Canadian provinces, Alberta and Nova Scotia, from 1990 to 2001. Can J Cardiol 2004;20:767-72.
8. Kephart G, Sketris I, MacLean D, et al. Management of high blood cholesterol levels in Nova Scotian adults: comparison with the NCEP II and European clinical practice guidelines. Am J Manag Care 2000;6:1017-28.
9. Brown LC, Johnson JA, Majumdar SR, et al. Evidence of suboptimal management of cardiovascular risk in patients with type 2 diabetes mellitus and symptomatic atherosclerosis. CMAJ 2004;171:1189-92.
10. Ko DT, Mamdani M, Alter DA. Lipid-lowering therapy with statins in high-risk elderly patients: the treatment-risk paradox. JAMA 2004;291: 1864-70.
11. Steinberg BA, Bhatt DL, Mehta S, et al. Nine-year trends in achievement of risk factor goals in the US and European outpatients with cardiovascular disease. Am Heart J 2008;156:719-27.
12. Mosca L, Merz NB, Blumenthal RS, et al. Opportunity for intervention to achieve American Heart Association guidelines for optimal lipid levels in high-risk women in a managed care setting. Circulation 2005;111:488-93.
13. Khan NA, McAlister FA, Campbell NRC, et al. The 2004 Canadian recommendations for the management of hypertension: part II: therapy. Can J Cardiol 2004;20:41-54.
14. McPherson R, Frohlich J, Fodor G, et al. Canadian Cardiovascular Society position statement: recommendations for the diagnosis and treatment of dyslipidemia and prevention of cardiovascular disease. Can J Cardiol 2006;22:913-27.
15. MacLean DR, Petrasovits A, Nargundkar M, et al. Canadian heart health surveys: a profile of cardiovascular risk: survey methods and data analysis. Canadian Heart Health Surveys Research Group. CMAJ 1992;146:1969-74.
16. Grover SA, Paquet S, Levinton C, et al. Estimating the benefits of modifying risk factors of cardiovascular disease. A comparison of primary vs secondary prevention. Arch Intern Med 1998;158:655-62.
17. Pate RR, Pratt M, Blair SN, et al. Physical activity and public health: a recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. JAMA 1995;273:402-7.
18. National Center for Health Statistics 2008. National Health and Nutrition Examination Study (NHANES). Available at: http://www.cdc.gov/nchs/nhanes.htm. Accessed January 15, 2009.
19. Fagard RH. Exercise is good for your blood pressure: effects of endurance training and resistance training. Clin Exp Pharmacol Physiol 2006;33: 853-6.
20. Leon AS, Sanchez OA. Response of blood lipids to exercise training alone or combined with dietary intervention. Med Sci Sports Exerc 2001; 33(suppl 6):S502-15.
21. Law MR, Wald NJ, Rudnicka AR. Quantifying effect of statins on low density lipoprotein cholesterol, ischaemic heart disease, and stroke: systematic review and meta-analysis. BMJ 2003;326:1-7.

22. Gardner CD, Kiazand A, Alhassan S, et al. Comparison of the Atkins, Zone, Ornish, and LEARN diets for change in weight and related risk factors among overweight premenopausal women: the A TO Z Weight Loss Study: a randomized trial. JAMA 2007;297:969-77.

23. Scandinavian Simvastatin Survival Study Group. Randomised trial of cholesterol lowering in 4444 patients with coronary heart disease: the Scandinavian Simvastatin Survival Study (4S). Lancet 1994;344:1383-9.

24. Taylor AJ, Sullenberger LE, Lee HJ, et al. Arterial Biology for the Investigation of the Treatment Effects of Reducing Cholesterol (ARBITER) 2: a double-blind, placebo-controlled study of extended-release niacin on atherosclerosis progression in secondary prevention patients treated with statins. Circulation 2004;110:3512-7.

25. Law MR, Wald NJ, Morris R, et al. Value of low dose combination treatment with blood pressure lowering drugs: analysis of 354 randomised trials. BMJ 2003;326:1427-34.

26. Heiss G, Tamir I, Davis CE, et al. Lipoprotein-cholesterol distributions in selected North American populations: the Lipid Research Clinics Program Prevalence Study. Circulation 1980;61:302-15.

27. Grover SA, Coupal L, Zowall H, et al. Cost-effectiveness of treating hyperlipidemia in the presence of diabetes: who should be treated? Circulation 2000;102:722-7.

28. Grover SA, Coupal L, Gilmore N, et al. Impact of dyslipidemia associated with highly active antiretroviral therapy (HAART) on cardiovascular risk and life expectancy. Am J Cardiol 2005;95:586-91.

29. Grover SA, Coupal L, Kaouache M, et al. Preventing cardiovascular disease among Canadians: What are the potential benefits of treating hypertension or dyslipidemia. Canadian J Cardiol 2007;23:467-73.

30. US Department of Health and Human Services. The Health Benefits of Smoking Cessation. Washington, DC: US Department of Health and Human Services, Public Health Service, Centers for Disease Control, Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health. 1990. DHHS pub no. (CDC) 90-8416.

31. Petrella RJ, Merikle E, Jones J. Prevalence and treatment of dyslipidemia in Canadian primary care: a retrospective cohort analysis. Clin Ther 2007; 29:742-50.

32. Leenen FH, Dumais J, McInnis NH, et al. Results of the Ontario survey on the prevalence and control of hypertension. CMAJ 2008;178:1441-9.

33. Kahn R, Robertson RM, Smith R, et al. The impact of prevention on reducing the burden of cardiovascular disease. Circulation 2008;118: 576-85.

34. Canadian Diabetes Association Clinical Practice Guidelines Expert Committee. Canadian Diabetes Association 2008 Clinical Practice Guidelines for the Prevention and Management of Diabetes in Canada. Can J Diabetes 2008;32(suppl 1):S1-201.

35. Chiuve SE, McCullough ML, Sacks FM, et al. Healthy lifestyle factors in the primary prevention of coronary heart disease among men: benefits among users and nonusers of lipid-lowering and antihypertensive medications. Circulation 2006;114:160-7.