Prevalence, Awareness, and Management of CKD and Cardiovascular Risk Factors in Publicly Funded Health Care

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Abstract

**Background and objectives** It is uncertain how many patients with CKD and cardiovascular risk factors in publicly funded universal health care systems are aware of their disease and how to achieve their treatment targets.

**Design, setting, participants, & measurements** The CARTaGENE study evaluated BP, lipid, and diabetes profiles as well as corresponding treatments in 20,004 random individuals between 40 and 69 years of age. Participants had free access to health care and were recruited from four regions within the province of Quebec, Canada in 2009 and 2010.

**Results** CKD (Chronic Kidney Disease Epidemiology Collaboration equation; <60 ml/min per 1.73 m²) was present in 4.0% of the respondents, and hypertension, diabetes, and hypercholesterolemia were reported by 25%, 7.4%, and 28% of participants, respectively. Self-awareness was low: 8% for CKD, 73% for diabetes, and 45% for hypercholesterolemia. Overall, 31% of patients with hypertension did not meet BP goals, and many received fewer antihypertensive drugs than appropriately controlled individuals; 41% of patients with diabetes failed to meet treatment targets. Among those patients with a moderate or high Framingham risk score, 53% of patients had LDL levels above the recommended levels, and many patients were not receiving a statin. Physician checkups were not associated with greater awareness but did increase the achievement of targets.

**Conclusion** In this population with access to publicly funded health care, CKD and cardiovascular risk factors are common, and self-awareness of these conditions is low. Recommended targets were frequently not achieved, and treatments were less intensive in those patients who failed to reach goals. New strategies to enhance public awareness and reach guideline targets should be developed.

**Introduction** Cardiovascular (CV) disease and CKD are global public health issues. In industrialized countries, the prevalence of CKD and ESRD is increasing. In Canada, the number of people living with ESRD tripled from 1991 to 2010 (1). CV risk factors and CKD can be screened effectively, and common treatments entail long-term benefits (2).

In the mostly private health care system of the United States, there is a lack of awareness of CKD and CV risk factors. Unequal access to health care is a determinant of awareness and management of these conditions (3–6). In European countries, where there is a mixture of public and private health care, target guidelines are also not met (7). Although the Canadian health care system is universally accessible and almost entirely publicly financed, it is uncertain how well it identifies and manages CV risk factors and CKD (8). In this context, to address the performance of a largely publicly funded health care system, we studied the prevalence and awareness of CV risk factors and CKD in a large random cohort of the Quebec general population. We also assessed how current treatment guidelines for hypertension, diabetes, and hypercholesterolemia are implemented.

**Materials and Methods**

**Study Design and Population** This study is a cross-sectional analysis of the CARTaGENE (CaG) survey performed between July of 2009 and October of 2010. CaG is a databank and biobank initiated as an infrastructure for population genomics research and created to develop better diagnosis, treatment, and disease prevention programs (http://www.cartagene.qc.ca/). A detailed description of the cohort and sampling method is provided elsewhere (9). Briefly, it includes 20,004 participants or 1% of the Quebec population ages 40–69 years. Participants were recruited randomly from the general population from four metropolitan regions of Quebec:

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76% of participants came from Montreal, 16% of participants came from Quebec City, 4% of participants came from Chicoutimi, and 4% of participants came from the Sherbrooke region. Candidates were identified using the provincial health insurance database, and invitations were sent by mail, with potential participants contacted by telephone (9). The survey excluded people living in institutions and on Aboriginal reserves. Of the initial study population, 45% of the population was not reached, 2% of the population was ineligible, 38% of the population refused (among which 95% of the population was not interested), and 1% of the population did not show up or sign the consent form, whereas 14% of individuals presented for the interview. The overall recruitment rate was 25% (14%/53%). Younger men were the least likely to participate (23%) compared with older men (28%) and women (26%). There was an overall concordance in the distribution of sociodemographic characteristics between the cohort and the general population. All participants signed an informed consent form. The study adhered to the Declaration of Helsinki. The survey included a lengthy health and lifestyle questionnaire, assessment of BP and anthropometric measurements, lung function tests, and an electrocardiogram. Serum, plasma, urine, and DNA samples were obtained.

**Questionnaire, Measurements, and Definitions**

The survey addressed sociodemographic determinants of health, such as ethnicity, educational background, and household income; health and lifestyle habits, such as last medical checkup and smoking status and frequency (past, occasional, or current); and self-declared diagnoses, including hypertension, hypercholesterolemia, diabetes (type 1 or 2), and cardiac (angina or myocardial infarction) or cerebral vascular disease, and medication usage. With regards to kidney disease, participants answered the following questions: Has a doctor ever told you that you had kidney disease, such as renal failure, renal infection, or kidney stones? What kind of kidney disease was it: renal failure, renal infection, kidney stones, or other? Do you or did you have dialysis treatment? Have you had a kidney transplant? Self-declared CKD included those participants who acknowledged renal failure, dialysis, or transplant or mentioned a condition associated with CKD in the other category. We excluded reported renal infections or kidney stones.

During the outpatient visit, the participants’ heights and weights were measured. BP was measured three times every 2 minutes after an initial 10-minute rest period. The diameter of the forearm determined the appropriate size cuff (BP monitor; Omron 907XL; Omron, Lake Forest, IL), and the mean of three measurements was reported. An elevated BP was defined as 140 mmHg or higher or a systolic pressure of 90 mmHg or higher. During the outpatient visit, the participants responded with the television questionnaire, Measurements, and Definitions.

**Results**

**Demographics**

The CaG cohort includes 20,004 individuals and is composed of 51% women. Ethnicity was self-reported, with a large majority (83%) of participants reporting Caucasian as their declared ethnicity. Among the remaining 17% of participants, 4% of participants had (at least) one parent born in Africa, 3% of participants had (at least) one parent born in Latin America and Asia, 4% of participants had (at least) one parent born in the Middle East, and 3% of participants reported ethnicity as other. The mean age was 54 years, 62% of participants completed college, and 12% of participants graduated from university. 31% of participants report an average household gross annual income (in Canadian dollars) < $50,000/year, 50% of participants report an average household gross annual income between $50,000 and $150,000/year, and 11% of participants report an average household gross annual income > $150,000/year. The majority (91%) had received a medical checkup recently, within the previous year for 74% of the participants.

**Prevalence and Awareness of CV Risk Factors**

The prevalence of self-reported hypertension was 25%; 12% of participants who did not declare a history of hypertension...
showed an elevated BP during the physical assessments, 11% of participants with no history of hypertension, CKD, or diabetes had BP measurements $>140/90$ mmHg, and 36% of participants with no history of hypertension but with either CKD or diabetes had BP measurements $>130/80$ mmHg.

Diabetes was reported by 7.4% of the participants, with type 1 diabetes accounting for 0.6% and type 2 diabetes accounting for 6.8%. In addition, 2.8% of the cohort had undiagnosed diabetes, raising the total patients with diabetes in the cohort to 10.2% (awareness of 73%). An additional 10% of participants were considered prediabetic.

Twenty-eight percent of the cohort reported having hypercholesterolemia. In fasting individuals with a complete lipid profile, 32% of participants had undiagnosed hypercholesterolemia (awareness of 45%). In the group with a high Framingham risk score, 71% of participants who declared having no prior hypercholesterolemia were unaware that they had higher LDL levels than the Adult Treatment Panel III target values. Among the moderate and low Framingham risk groups, 58% and 10% of participants, respectively, had elevated LDL levels.

Five percent of individuals reported a history of coronary artery disease; 1.6% of individuals reported cerebral vascular disease. Finally, 15% of the participants reported that they smoked daily, 4% of the participants reported that they smoked occasionally, 40% of the participants reported that they had previously stopped, and 41% of the participants reported that they had never smoked.

### Prevalence and Awareness of CKD

Excluding urinary infections, 6.9% of respondents reported a history of kidney disease, most often kidney stones (5.5%), with 161 (0.8%) respondents mentioning a condition compatible with CKD. This group included individuals having answered positively to renal failure ($n=110$), dialysis ($n=19$), or transplantation ($n=13$) or mentioned a condition in the other renal disease category, such as GN ($n=10$), polycystic renal disease ($n=4$), or renal artery disease ($n=3$), that is likely to cause a decrease in renal function.

Serum creatinine was measured for 19,435 participants. Based on the CKD-EPI formula, the mean eGFR in the total sample was $88\pm15$ ml/min per 1.73 m$^2$, and the prevalence of an eGFR $<60$ ml/min per 1.73 m$^2$ was 4.0%. We also report MDRD eGFRs in Table 1. Demographic and CV risk factors associated with stages 3–5 CKD are listed in Table 2.

Among individuals with an eGFR $<60$ ml/min per 1.73 m$^2$, 8% of individuals were aware of their kidney condition. Men were more aware than women (12% versus 4.8%, $P<0.001$), and younger individuals (13% in the 40–49 years group versus 6.1% in the 60–69 years group, $P<0.001$) were more aware than older individuals. Awareness was modestly higher in individuals with preexisting comorbidities. In those individuals reporting hypertension, hypercholesterolemia, CV disease, or diabetes, awareness was notably higher in individuals with preexisting comorbidities. Taken together, 68% of participants unaware of CKD had at least one of those three CV risk factors. Awareness of CKD did increase from 3.8% to 8.1% to 11.0% in the low, moderate, and high Framingham risk groups, respectively ($P<0.001$). Ethnicity, educational level, household income, body mass index, smoking history, and having received a medical checkup were not associated with awareness of CKD (data not shown). Finally, multivariate analysis showed that lower age, being a man, self-reported hypertension, hypercholesterolemia, and diabetes were independently associated with CKD awareness (Table 3).

### Management of Self-Declared CV Risk Factors

Among the individuals who reported hypertension without diabetes or CKD, 31% of individuals had high BP $\geq 140/90$ mmHg at the time of the clinic visit, whereas 53% of individuals who reported diabetes or CKD had a BP $\geq 130/80$ mmHg. The types of antihypertensive medications were similar in CKD and non-CKD groups (Figure 1). Individuals with hypertension with a higher CV risk were more likely to receive antihypertensive drugs (61%, 74%, and 87% in the low, moderate, and high risk groups, respectively, $P<0.001$). However, patients with hypertension with inadequate control used fewer antihypertensive medications ($P<0.001$) (Figure 2).

Thirty-eight percent of patients with self-reported diabetes had an HbA1c $\geq 7.1\%$. In those individuals treated with diet therapy, oral hypoglycemic agents, and insulin, this number increased from 20% to 39% to 73% ($n=165$) (Figure 3). This finding applied equally to CKD and non-CKD individuals.

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### Table 1. Estimated GFR and CKD awareness

| eGFR$^a$ | CKD-EPI Equation | MDRD Equation |
|----------|------------------|---------------|
|          | N     | Percent | Aware (%) | N     | Percent | Aware (%) |
| $\geq 90$ | 9530  | 49      | —         | 5493  | 28      | —         |
| 60–89    | 9123  | 47      | —         | 12,608 | 65      | —         |
| 45–59    | 662   | 3.4     | 4         | 1181  | 6.1     | 3         |
| 30–44    | 103   | 0.5     | 22        | 137   | 0.7     | 19        |
| 15–29    | 12    | 0.07    | 75        | 11    | 0.1     | 82        |
| $<15$    | 5     | 0.03    | 100       | 5     | 0.03    | 100       |
| Total    | 19,435| 8       | —         |       |         | —         |

CKD-EPI, Chronic Kidney Disease Epidemiology Collaboration; MDRD, Modification of Diet in Renal Disease.

$^aExpressed in milliliters per minute per 1.73 meters$^2$. The serum creatinine was unavailable in 569 individuals.
Among the individuals who self-reported hypercholesterolemia, 56% of individuals were taking a statin, and 1.5% of individuals received a fibrate or niacin. About one half of those individuals with self-declared hypercholesterolemia and a moderate or high Framingham risk score had LDL levels above target (Figure 4). Among these individuals, only 35% received statins as opposed to 81% received statins in those individuals who reached their goal ($P$, 0.001). Two times as many men were not on treatment target compared with women (41% versus 23%). Lower education level was associated with participants failing to meet targets for hypertension or diabetes, and lower income was associated with failure to reach lipid treatment goals (data not shown). Participants with routine medical visits attained treatment targets for CV risk factors more frequently: 74% of individuals with hypertension and regular checkups reached BP targets compared with 54% of individuals with hypertension and without regular checkups ($P$, 0.001). Patients with diabetes without regular visits had a worse glycemic control (HbA1c>8.5% in 23% compared with 13% of participants, $P$,0.02). In the low Framingham risk group, the LDL levels were on target more often in those individuals with regular medical visits (86% versus 71%, $P$,0.05). However, this difference was not observed in the median and high Framingham risk groups.

Discussion

Awareness of hypertension, diabetes, hypercholesterolemia, and CKD has profound public health consequences given the available and effective management strategies and guidelines. In this large random population survey of adults ages 40–69 years, the prevalence of CKD defined by an eGFR<60 ml/min per 1.73 m$^2$ was 4.0%. Hypertension

| Characteristic                        | CKD-EPI≥60 ml/min per 1.73 m$^2$ (n=18,653) | CKD-EPI<60 ml/min per 1.73 m$^2$ (n=782) | $P$ Value |
|--------------------------------------|---------------------------------------------|----------------------------------------|-----------|
| Age (yr)                             | 54±8                                        | 61±7                                   | <0.001    |
| Women (%)                            | 51                                          | 51                                     | 0.96      |
| Caucasian ethnicity                  | 84                                          | 87                                     | 0.71      |
| Higher education (%)                 | 74                                          | 67                                     | <0.001    |
| Yearly income<$50,000                | 36                                          | 50                                     | <0.001    |
| Hypertension (%)                     | 24                                          | 48                                     | <0.001    |
| Hypercholesterolemia (%)             | 28                                          | 43                                     | <0.001    |
| Diabetes, type 1 or 2 (%)            | 7                                           | 20                                     | <0.001    |
| Body mass index>30 kg/m$^2$ (%)      | 26                                          | 35                                     | <0.001    |
| **Smoking (%)**                      |                                              |                                        |           |
| Never, past, occasional, current     | 41, 40, 4, 15                               | 38, 46, 4, 11                          | 0.01      |
| **Framingham risk group**            |                                              |                                        |           |
| Low, moderate, high                  | 55, 22, 23                                  | 21, 24, 45                             | <0.001    |
| Medical follow-up                    | 91                                          | 96                                     | <0.001    |
| History of coronary artery disease (%)| 5                                           | 12                                     | <0.001    |
| History of cerebrovascular disease (%)| 1.5                                         | 4.3                                    | <0.001    |

$^a$College or university.
$^b$Self-reported.

**Table 2.** Population characteristics according to CKD status

**Table 3.** Independent predictors of awareness to CKD

| Characteristic                        | OR   | 95% CI     | $P$ Value |
|--------------------------------------|------|------------|-----------|
| Age (yr)                             | 0.93 | 0.89 to 0.96 | <0.001    |
| Men                                  | 2.2  | 1.2 to 3.8   | 0.01      |
| Self-reported hypertension            | 1.9  | 1.1 to 3.5   | 0.03      |
| Self-reported hypercholesterolemia   | 2.2  | 1.2 to 3.9   | 0.01      |
| Self-reported diabetes                | 2.3  | 1.3 to 4.3   | 0.01      |

OR, odds ratio; 95% CI, 95% confidence interval.
was present in at least 25% of individuals, diabetes was present in 10% of individuals, and hypercholesterolemia was present in 28% of individuals. Awareness of these conditions was low: only 8% for CKD, 73% for diabetes, and 55% for hypercholesterolemia. Awareness of hypertension could not be determined in our study design, because the diagnosis of hypertension requires multiple measurements. Access to primary care, income, and education were not associated with awareness of these conditions but did improve the fulfillment of treatment goals.

CV risk factors were highly prevalent in the present survey and similar to the results of other previous Canadian (16), United States (17), and European studies (18). Patients with uncontrolled hypertension used fewer antihypertensive drugs than controlled hypertensive individuals, suggesting undertreatment rather than resistant hypertension. The prevalence of diabetes in the United States population >20 years of age stands at 9.6%, with one fifth of cases undiagnosed, which was similar to our population (19). Management of diabetes was also suboptimal: 41% of the patients with diabetes in this cohort failed to meet treatment targets based on HbA1c, which was similar to findings of other studies (20,21). We also uncovered a high proportion of individuals unaware of hypercholesterolemia, and many individuals with self-declared hypercholesterolemia who did not meet treatment targets were not receiving any therapy. Insufficient therapy in the groups failing to meet targets could be secondary to intolerance to medications, although we believe that it would only explain a minority of cases. Affordability of medication may play a role. However, every individual in the province adheres to a drug plan that is provided by the workplace, the government, or a private insurance, which covers most of the cost (22).

The prevalence of stages 3–5 CKD in CaG was similar to reports from Europe (23) and the United States (24). It can vary according to the formula used to estimate GFR. The CKD-EPI formula classifies fewer individuals in the lower CKD categories compared with the MDRD equation (25) and offers a more accurate risk prediction of mortality and ESRD (26). Awareness of CKD was low in the present survey. Only 8% of participants with CKD were aware of their renal condition. It is possible that they had not recently seen their physician or had forgotten their condition. Systematic reporting of eGFR with creatinine has recently been implemented in Quebec but may not have been available at the time of the study. Reporting has been associated with greater identification of patients with CKD in different countries (27). Individuals >60 years of age with a borderline creatinine may have previously gone unnoticed. Therefore, awareness may now have increased.

Studies from the United States report a similar prevalence of CKD awareness with a greater proportion in men...
However, contrary to other reports, we found that regular physician visits were not associated with greater awareness (28,29), although they did translate into better hypertension, diabetes, and hypercholesterolemia management. Similarly, we did not find that education and income influenced awareness, but they influenced the achievement of treatment goals. Access to health care may be less dependent on education and income levels in the public Canadian health care system (30,31). The Kidney Early Evaluation Program study recently addressed awareness of CKD in the United States and concluded that it was not related to the presence or type of health insurance coverage or the additional availability of prescription medication coverage (32). Shah et al. (32) suggested that access to routine primary care may be a more important determinant of CKD awareness than health insurance coverage. Other tools may influence awareness, such as education programs initiated to emphasize the importance of kidney disease (National Heart, Lung, and Blood Institute Global Health Strategic Plan, Centers for Disease Control and Prevention Chronic Kidney Disease Initiative, Healthy People Goal 2020, and New Challenge Campaign). A meta-analysis of all studies comparing health outcomes for similar conditions in Canada and the United States (8) concluded that health outcomes may be superior in patients cared for in Canada versus the United States, but differences are inconsistent.

Certain limitations must be noted. We cannot exclude that a selection bias was introduced in the recruitment of the cohort. Individuals were recruited from specific geographical areas thought to be representative of the province of Quebec. Similarly, the European Action on Secondary Prevention by Intervention to Reduce Events study included only one geographical area for each of 12 countries (7). The participation rate was relatively low (33). Hence, our results may not reflect the Canadian population. The specific reasons for the low rates of enrollment are unclear, but the lengthy questionnaire and physical examination could have been a deterrent. Also, the CaG survey was not specifically conceived to address CKD. The present study is cross-sectional and contains a single serum creatinine measurement, which is similar to other studies (32). However, the diagnosis of CKD requires multiple values. A large population study has shown that a single measurement in creatinine can overestimate the diagnosis of stages 3–5 CKD from 5.5% to 6.4% (34) compared with using more than one value. Similarly, BP was also measured in one single visit, and our results may not represent true BP control. Fasting blood samples were available for only a minority of the participants, limiting our assessment of hypercholesterolemia and diabetes in our population. In studying individuals 40–69 years old, our results may not be applicable to younger or older subjects. Urinary albumin excretion results were not available for analysis and would have allowed accurate classification of stages 1 and 2 CKD. Finally, we present LDL treatment targets based on United States recommendations, because we could not address the change in LDL values during therapy specified by the Canadian guidelines (35). The small differences in targets between the United States and Canada recommendation are unlikely to change the conclusions significantly.

In summary, in this large sample of the general population, stages 3–5 CKD was present in 4.0% of the population. Most individuals were unaware of their kidney condition, even high-risk individuals. CV risk factors were prevalent. Management targets were frequently not achieved, and treatments were less intensive in those individuals who failed to reach goals. These findings underline the necessity for renewed efforts for CKD and CV risk factors screening, enhanced patient education, and aggressive treatment of these conditions.

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Disclosures
None.

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