Risk Factors for Cardiovascular Disease in Homeless Adults

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Background—Homeless people represent an extremely disadvantaged group in North America. Among older homeless men, cardiovascular disease (CVD) is the leading cause of death. The objective of this study was to examine cardiovascular risk factors in a representative sample of homeless adults and identify opportunities for improved risk factor modification.

Methods and Results—Homeless persons were randomly selected at shelters for single adults in Toronto. Response rate was 79%. Participants (n=202) underwent interviews, physical measurements, and blood sampling. The mean age of participants was 42 years, and 89% were men. The prevalence of smoking among homeless subjects (78%; 95% confidence interval [CI], 72% to 84%) was significantly higher than in the general population (standardized morbidity ratio [SMR], 254; 95% CI, 216 to 297). Hypertension, high cholesterol, and diabetes were not more prevalent than in the general population but were often poorly controlled. Homeless men were significantly less likely to be overweight or obese than men in the general population (SMR, 79; 95% CI, 63 to 98). Cocaine use in the last year was reported by 29% of subjects (95% CI, 23% to 36%). CVD was reported by 15% of subjects, fewer than one third of whom reported taking aspirin or cholesterol-lowering medication. According to multiple-risk-factor equations, the median estimated 10-year absolute risk of myocardial infarction or coronary death among homeless men aged 30 to 74 years was 5% (interquartile range, 3% to 9%).

Conclusions—Cardiovascular risk factor modification is suboptimal among homeless adults in Toronto, despite universal health insurance. Multiple risk factor equations may underestimate true risk in this population because of inadequate accounting for factors such as cocaine use and heavy smoking. (***Circulation*. 2005;111:2629-2635.)**

Key Words: risk factors ■ prevention ■ cardiovascular diseases ■ homeless persons ■ hypertension

A growing body of research has focused on the socioeconomic disparities in risk factors, prevalence, and treatment of cardiovascular disease (CVD).[1–4] Nevertheless, relatively little attention has been paid to cardiovascular health in one of the most disadvantaged groups in society—people who are homeless. Homelessness is a widespread problem in the United States: It is estimated that 800 000 Americans are homeless in any given week and that 5 to 8 million have experienced homelessness in the past 5 years.[5,6] In cities such as Philadelphia and New York, ≈1% of the entire population has stayed at a homeless shelter in the past year.[7] In Toronto, Canada, ≈30 000 people (1.3% of the city's residents) used a homeless shelter during 2002.[8] Homelessness affects people of all ages, including adolescents, adult men, adult women, and families comprising parents and children. These subgroups represent ≈9%, 60%, 16%, and 15% of the US homeless population, respectively.[5]

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CVD is a major cause of morbidity and mortality among homeless adults. Homeless men 45 to 64 years of age are 40% to 50% more likely to die of heart disease than men in the general population, and heart disease is the leading cause of death in older homeless men.[9,10] This observation may be explained in part by a high prevalence of traditional cardiovascular risk factors among homeless people, as well as barriers to appropriate risk factor management. For example, smoking is common among homeless individuals,[11–14] and adequate control of hypertension and diabetes is often difficult.[15,16] Homeless people's diets are often high in saturated fats and cholesterol and inadequate in essential nutrients, contributing to adverse lipid profiles.[17]

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Previous studies of cardiovascular risk factors in homeless people have been limited by their focus on a single cardiovascular risk factor[13–17] or characterization of a group of homeless clinic patients who likely differ substantially from the general homeless population.[12] No published study provides a comprehensive cardiovascular risk profile in a representative sample of homeless individuals. This information would be an essential first step toward improving cardiovascular health in this extremely disadvantaged population. We therefore conducted this study in a representative sample of adults at homeless shelters in Toronto to examine multiple risk factors for CVD, determine the estimated 10-year risk of a cardiovascular event, and identify opportunities for improved risk factor modification in this population.

Methods

Study Population

All study participants were adults who were staying at homeless shelters in Toronto, Ontario. Adults accompanied by their dependent children were excluded because previous studies have shown large differences in the characteristics of homeless families and single adults.[5] Persons staying at shelters for homeless youth (aged 15 to 24 years) were excluded because of the extremely low risk of CVD in this age range. At the time of this study, Toronto had 35 homeless shelters for adults. Recruitment took place at the 12 largest of these shelters and a random sample of 5 additional shelters. The number of participants recruited at each shelter was equal to ≈8% of the shelter's overnight capacity.

A random-number generator was used to select individuals on the shelter's registration list for recruitment into the study. Three attempts were made to locate a selected individual; if these efforts were unsuccessful, the person in the next consecutive bed was approached. Recruitment took place between March 2002 and March 2003. All participants gave written, informed consent and received a $5 payment. The Research Ethics Board at St. Michael's Hospital approved this study.

Survey Interview and Physical Measurements

Subjects underwent a face-to-face survey, physical measurements, and blood sampling. The questionnaire obtained demographic and social information and medical history, including cardiovascular risk factors and the presence of overt CVD. Coronary artery disease (CAD) was defined as heart attack, angina, coronary angioplasty, or bypass surgery. CVD was defined as CAD, peripheral vascular disease, or stroke. Peripheral vascular disease was defined as self-reported blockage of the arteries in the legs or previous angioplasty of a leg artery. Subjects were provided with simplified definitions of medical conditions and procedures (see online-only Appendix). Data were obtained on the use of prescription and over-the-counter medications, street drugs, and alcohol. The CAGE questionnaire was used to screen for alcohol abuse. A series of structured questions was used to determine family history of premature CAD (defined as CAD before age 55 in a father or brother or before age 65 in a mother or sister).

Physical measurements included height and weight. Weight was measured without shoes on a portable digital scale (Stayfit, Mansfield Medical Distributors). Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared and categorized according to World Health Organization (WHO) criteria as underweight (BMI <18.5), normal (BMI $=18.5$ to 24.9), overweight (BMI $=25.0$ to 29.9), or obese (BMI ≥ 30.0).[18,19] Waist circumference was measured at the midpoint between the bottom of the rib cage and the iliac crest, and abdominal obesity was defined as a waist circumference >102 cm in men or >88 cm in women.[20,21]

With the subject seated comfortably, blood pressure was measured 4 times (twice in each arm) with an automatic blood pressure monitor (Omron model HEM-711AC, Omron Healthcare Canada). All analyses reported in this article used the mean systolic and diastolic pressures based on the 4 measurements. In a secondary analysis, the mean systolic and diastolic pressures were calculated for each arm, and the mean values from the arm with the higher mean systolic pressure were used. Blood pressure was classified according to the criteria of the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7).[22]

Biological Markers

Nonfasting blood samples were obtained from participants, placed in a 50:50 ice/water mixture, and transported to the laboratory within 4 hours of collection. Plasma homocysteine levels were measured by competitive immunoassay with the Immulite 2000 (Diagnostic Products Corp). Serum was separated in a refrigerated centrifuge within 1 hour of arrival. Serum high-sensitivity C-reactive protein (hs-CRP) concentration was determined with the Behring BN100 (Dade-Behring).

Serum lipids and lipoprotein profiles were determined with the Lipid Research Clinics protocol.[23] VLDL and chylomicrons were isolated by ultracentrifugation of serum at 45 000 rpm for 16.5 hours at 10°C. HDL was measured from the infranatant after dextran sulfate–$MgCl_2$ precipitation.[24] Cholesterol and triglyceride were measured by automatic enzymatic procedures with the Bayer RA1000 (Bayer, Inc). These methods permit accurate calculation of LDL in a nonfasting sample.

Because it was not feasible to obtain fasting blood glucose or oral glucose tolerance tests in this homeless population, we measured hemoglobin A_{1c} (HbA_{1c}) levels. Individuals were considered to have diabetes if they self-reported having diabetes or if their HbA_{1c} levels were $>6.1\%$ (>2 SD above the mean). This HbA_{1c} criterion has been shown to have 97% specificity and 63% sensitivity for detecting previously undiagnosed diabetes in the general population.[25] Poor diabetic control was defined as an HbA_{1c} level $>8.4\%$, in keeping with previous Canadian consensus recommendations.[26]

Cardiovascular Risk Assessment

We used Framingham multiple-risk-factor equations to estimate the 10-year risk for developing coronary heart disease (CHD), based on age, sex, total cholesterol level, HDL cholesterol level, mean systolic blood pressure, diabetes status, and smoking status.[27] Risk estimates were performed for "hard" CHD, defined by the Framingham investigators as coronary death or clinical evidence of myocardial infarction (MI). Men under the age of 30 years and women under the age of 40 years were excluded from these analyses because standard multiple-risk-factor equations do not apply to these age groups. Adult Treatment Panel III (ATP III) guidelines were used to classify cholesterol levels, identify each subject's target LDL, and determine whether lifestyle modification or drug therapy to lower LDL would be recommended.[28] hs-CRP levels were classified as low (<1 mg/L), average (1 to 3 mg/L), or high (3 to 10 mg/L) risk for CHD or consistent with infection or inflammation (>10 mg/L).[29] Homocysteine levels were categorized as low (<10 μmol/L), intermediate (10 to 15 μmol/L), or high (>15 μmol/L).[30]

Comparisons With the General Population

The standardized morbidity ratio (SMR) was calculated as the observed number of homeless study participants with a particular cardiovascular risk factor divided by the expected number based on the assumption that the risk factor prevalence in study participants was the same as that in the general population.[31] Data on the age- and sex-specific prevalences of cardiovascular risk factors in the general population were obtained from published sources. Whenever possible, residents of Toronto or Ontario were used as the reference population; if these data were unavailable, residents of Canada were used as the reference population. An SMR of 100 indicates that the prevalence of the risk factor is at the expected level; an SMR >100 indicates higher prevalence than expected, and an SMR <100 indicates lower prevalence than expected. The 95% confidence

TABLE 1. Demographic and Social Characteristics of Study Participants (n=202)

Age	
Mean±SD, y	42.3±11
Range, y	20–74
Sex	
Male	179 (89)
Female	23 (11)
Race	
White	136 (67)
Black	28 (14)
Aboriginal	16 (8)
Asian	8 (4)
Hispanic	5 (3)
Other	9 (5)
Education	
Did not complete high school	87 (43)
Completed high school	54 (26)
Some postsecondary education	22 (11)
Completed postsecondary education	38 (19)
Duration of current episode of homelessness	
Median, mo	6
Interquartile range, mo	2–20
Duration spent homeless in lifetime	
Median, mo	24
Interquartile range, mo	6–72
Marijuana used in the past 12 months	86 (43)
Amphetamine used in the past 12 months	10 (5)
Alcohol used in the past 48 hours	47 (23)
CAGE score	
0	94 (47)
1	16 (8)
2	31 (15)
3	24 (12)
4	37 (18)

Values are given as n (%) unless otherwise specified.

intervals (CIs) for SMRs were calculated with the Poisson process approximation.

Data on age, sex, and income quintile-specific prevalence rates of diabetes among residents of Ontario were obtained from the Ontario Diabetes Database.[32] Data on the age- and sex-specific prevalences of smoking in the general population of Canada were obtained from Statistics Canada.[33] Sex-specific data on measured blood pressure levels and the proportion of hypertensive persons aware of having hypertension and/or taking antihypertensive medications in the general population of Canada aged 35 to 64 years were obtained from the Canadian Heart Health Surveys.[34,35] Data on the sex-specific prevalence of overweight or obesity among residents of Toronto aged 20 to 64 years were obtained from Statistics Canada.[36]

Results

Of 279 individuals approached, 202 (72%) agreed to participate in the study. Demographic and social characteristics and substance use history of participants are shown in Table 1. Self-reported CVD, risk factors for CVD, and use of relevant prescription medications are shown in Table 2. Physical measurements and biological markers associated with cardiovascular risk are shown in Table 3. SMRs for major cardiovascular risk factors, comparing homeless study participants with the general population, are shown in Table 4.

TABLE 2. Self-Reported Prevalence of and Risk Factors for CVD and Relevant Medication Use in Study Participants

Characteristic	No.	% (95% CI)
CVD		
Angina	16	8 (5–13)
Heart attack	19	9 (6–14)
Coronary angioplasty or bypass surgery	7	4 (2–7)
Any CAD*	28	14 (10–19)
Stroke	5	3 (1–6)
Peripheral vascular disease	6	3 (1–7)
Any CVD†	30	15 (11–20)
Risk factors for CVD		
Hypertension	41	20 (15–27)
High cholesterol	29	14 (10–20)
Diabetes (self-reported)	14	7 (4–11)
Family history of premature CAD	48	24 (18–30)
Cigarette smoking		
Current smoker	158	78 (72–84)
Previous smoker	17	
Never smoker	27	
Pack-years of smoking, among current smokers		
Median, pack-years	23	
Interquartile range, pack-years	12–37	
Cocaine use in the past 12 months	59	29 (23–36)
Medication use		
Antihypertensive medications	13	6 (4–11)
Cholesterol-lowering medications	9	5 (2–8)
Oral hypoglycemic medication and/or insulin	12	6 (3–10)
Aspirin, daily use	14	7 (4–11)
Antibiotics and/or antiinflammatory medications	7	4 (2–7)

*CAD was defined as angina, heart attack, coronary angioplasty, or bypass surgery.

†CVD was defined as CAD, peripheral vascular disease, or stroke.

The self-reported prevalence of diabetes among homeless adults was 7% (95% CI, 4% to 11%). Although 12 of 14 (86%) individuals with self-reported diabetes were taking oral hypoglycemic agents or insulin, 6 of 14 (43%) had poor glycemic control as defined by a HbA_{1c} level >8.4%. Only 1 individual appeared to have previously undiagnosed diabetes on the basis of an elevated HbA_{1c}.

The prevalence of cigarette smoking among homeless people was extremely high at 78% (81% among men and 57% among women) (95% CI, 72% to 84%). Among homeless smokers, the median lifetime exposure was 23 pack-years.

Evaluated on the basis of a mean systolic blood pressure ≥140 mm Hg or a mean diastolic blood pressure ≥90 mm Hg, 35% (95% CI, 29% to 42%) of homeless subjects had hypertension. Among the 77 individuals who

TABLE 3. Physical Measurements and Biological Markers in Study Participants

Characteristic	No.	%	95% CI*
Blood pressure†			
Normal (SBP <120 and DBP <80 mm Hg)	33	16	
Prehypertension (SBP 120–139 or DBP 80–89 mm Hg)	97	48	
Stage 1 hypertension (SBP 140–159 or DBP 90–99 mm Hg)	59	29	
Stage 2 hypertension (SBP ≥160 or DBP ≥100 mm Hg)	12	6	
Not measured	1	1	
Stage 1 or 2 hypertension	71	35	29–42
BMI, kg/m^2			
Underweight (<18.5)	7	4	
Normal (18.5–24.9)	99	49	
Overweight (25.0–29.9)	51	25	
Obese (≥30.0)	42	21	
Not measured	3	2	
Overweight or obese	93	46	39–53
Abdominal obesity			
Absent	145	72	
Present	57	28	22–35
LDL cholesterol			
Optimal (<2.59 mmol/L, <100 mg/dL)	63	31	
Near optimal/above optimal (2.60–3.36 mmol/L, 100–129 mg/dL)	68	34	
Borderline high (3.37–4.14 mmol/L, 130–159 mg/dL)	45	22	
High (4.15–4.91 mmol/L, 160–189 mg/dL)	11	5	
Very high (≥4.92 mmol/L, ≥190 mg/dL)	5	3	
Not measured	10	5	
High or very high	16	8	5–13
HDL cholesterol			
Low (<1.04 mmol/L, <40 mg/dL)	76	38	
Intermediate (1.04–1.55 mmol/L, 40–59 mg/dL)	89	44	
High (≥1.56 mmol/L, ≥60 mg/dL)	30	15	11–20
Not measured	7	4	
HbA_{1c}			
Normal (≤6.1%)	169	84	
Elevated (consistent with diabetes) (>6.1%)	8	4	2–8
Not measured	25	12	
hs-CRP			
Low risk (<1.0 mg/L)	69	34	
Average risk (1.0–3.0 mg/L)	66	33	
High risk (3.1–10.0 mg/L)	43	21	16–27
Consistent with infection or inflammation (>10.0 mg/L)	17	8	
Not measured	7	4	
Homocysteine			
Low (<10 μmol/L)	114	56	
Intermediate (10–15 μmol/L)	57	28	
High (>15 μmol/L)	14	7	4–11
Not measured	17	8	

SBP indicates systolic blood pressure; DBP, diastolic blood pressure.
*95% CI given for prevalence of risk factor, dichotomized as present or not present.
†Mean of 4 measurements.

TABLE 4. SMR for Cardiovascular Risk Factors, Comparing Homeless Study Participants With the General Population

Risk Factor	SMR (95% CI)
Diabetes*	111 (61–186)
Smoking†	254 (216–297)
Hypertension (SBP ≥140 or DBP ≥90 mm Hg)‡	114 (89–144)
Overweight or obese (BMI ≥25 kg/m^2)§	79 (63–98)

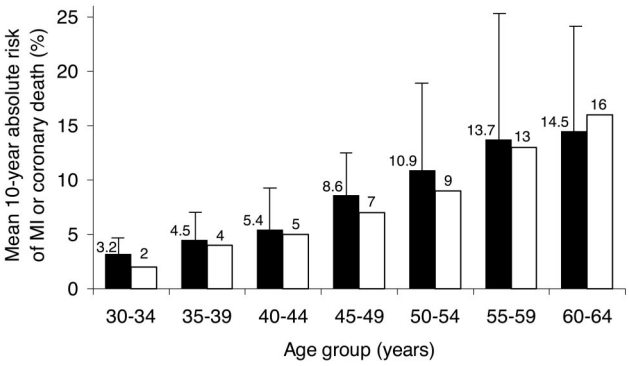
SBP indicates systolic blood pressure; DBP, diastolic blood pressure.

*Compared with an age- and sex-matched group of low-income individuals in the general population of Ontario.[32]

†Compared with an age- and sex-matched group of individuals in the general population of Canada.[33]

‡Compared with a sex-matched group of individuals aged 35 to 64 years in the general population of Canada.[34]

§Compared with an age-matched group of men in the general population of Toronto.[36]



Box-and-whisker plot showing estimated mean and SD 10-year absolute risk of MI or coronary death among homeless men in Toronto, Canada (black) and men in Framingham population (white).

had hypertension (assessed by blood pressure measurement or current treatment with antihypertensive medication), only 25 (33%) were aware of having hypertension, and only 13 (17%) were currently taking antihypertensive medication. The prevalence of hypertension in homeless persons aged 35 to 64 was not significantly different from what would be expected on the basis of data for the general population of Canada (Table 4). However, ≈57% of hypertensive individuals in the general population are aware of having hypertension,[35] and 36% are taking antihypertensive medication.[34]

The BMI of 46% (95% CI, 39% to 53%) of homeless subjects met WHO criteria for being overweight or obese (BMI ≥25). Homeless men were significantly less likely to be overweight or obese than men in the general population of Toronto (Table 4). However, only 4% (95% CI, 1% to 7%) of homeless individuals were underweight by WHO criteria.

Data on 179 subjects were sufficient to determine individualized cholesterol management recommendations according to ATP III guidelines. Lifestyle changes to lower LDL cholesterol would be recommended in 56 (31%) of these subjects. ATP III guidelines would recommend consideration of drug therapy to lower LDL cholesterol in 29 subjects (16%). Among these individuals, only 1 reported currently taking cholesterol-lowering medication. A clinical history of CVD was reported by 30 subjects (15%), of whom only 6 (20%) reported that they were currently taking cholesterol-lowering medication, and only 9 (30%) reported current use of aspirin.

hs-CRP levels indicative of high risk for CHD (3 to 10 mg/L) were present in 21% of subjects. Among homeless men, 24 of 174 (14%) had hs-CRP levels of 5 to 10 mg/L; 10% of men in the NHANES III population had hs-CRP levels in this range.[37] According to recent recommendations, hs-CRP may be used in clinical practice to help identify patients without known CVD who are estimated to have intermediate (10% to 20%) 10-year risk of CHD by standard risk factor assessment but who may actually have higher absolute risk on the basis of an elevated hs-CRP and might therefore benefit from more intensive intervention.[29] In our study population, 7 of 33 individuals (21%) in the intermediate-risk stratum had hs-CRP levels indicative of high risk.

Our study included 172 subjects without known CVD. Ten-year cardiovascular risk could not be calculated for 18 men under the age of 30 years and 13 women under the age of 40 years, because Framingham multiple-risk-factor equations do not apply to these age/sex groups. Ten-year risk could not be calculated for 4 of the remaining individuals because data on blood pressure or cholesterol levels were missing. Thus, we were able to estimate 10-year cardiovascular risk for 137 individuals (130 men and 7 women). Data on women are not reported because of small sample size. The relative risk of CHD among homeless men aged 30 to 74 years, as compared with the baseline risk conferred by age alone in the absence of other major risk factors, was 2.4±1.4 (mean±SD). The median estimated 10-year absolute risk of MI or coronary death among homeless men aged 30 to 74 years was 5% (interquartile range, 3% to 9%). The Figure shows the mean estimated absolute risk among homeless men, by age group. Because of the relatively small number of homeless men in each age group, these estimates have wide CIs and do not differ significantly from the mean risk levels observed among men in the Framingham population (Figure).[27]

Discussion

Homeless people represent one of the most socially and economically disadvantaged populations in North America. This study, which is the first to comprehensively assess cardiovascular risk factors in a representative sample of homeless adults, demonstrates high prevalence and severity of many major risk factors in this group of individuals. The prevalence of smoking, but not diabetes, hypertension, or elevated BMI was significantly higher among homeless adults than in the general population. However, there was evidence of inadequate diagnosis and treatment of hypertension and high cholesterol and poor control of diabetes. Homeless persons with a history of CVD appeared to be undertreated, when assessed by the small proportion of these individuals taking aspirin or cholesterol-lowering medication.

In addition to traditional risk factors, a number of other features present in the homeless population may contribute to high morbidity and mortality due to CVD. Substance use is common, with 30% of subjects having CAGE scores strongly

suggestive of alcoholism and 29% reporting cocaine use in the last 12 months. Cocaine use and excessive alcohol intake are clearly associated with an increased likelihood of CAD.[38,39] The role of newer serum markers such as homocysteine and CRP must also be considered. Homocysteine levels >15 μmol/L have been correlated with an elevated risk of CAD[30]; 7% of homeless subjects were in this range. Homeless people may be predisposed to elevated homocysteine levels because of high rates of smoking and inadequate dietary intake of B vitamins and folate.[40] In addition, an elevated hs-CRP value may identify a subgroup of homeless patients who are at higher absolute risk for CAD than that estimated by currently used multiple-risk-factor equations.

It is important to note that the mean estimated 10-year absolute risk of MI or coronary death among homeless men was not greatly elevated compared with that observed among men in the Framingham population. This finding is not consistent with previous studies documenting high mortality rates due to CVD in homeless persons.[9,10] One possible explanation is that multiple-risk-factor equations do not adequately account for risk factor severity; as a result, Framingham scores underestimate the true absolute risk in persons with heavy cigarette smoking, severe hypertension, and severe hypercholesterolemia.[27] Risk factors that are not considered by these equations, particularly cocaine use, may contribute substantially to increased cardiovascular risk in the homeless population. In older homeless men, another possible explanation for lower-than-expected CHD risk is the "healthy survivor" effect. Finally, the "average" risk of CHD was based on a cohort of men living in Framingham in the 1970s and may overestimate the average risk in a modern-day general population receiving the current standard of care.

This study has a number of limitations. Selection bias may have compromised our efforts to obtain a representative sample of homeless adults. Our study population (mean age, 42.3 years; 89% male, 67% white) was older and had more males than a previous study of 300 homeless adults in Toronto (mean age, 33.4 years; 78% male, 73% white) that was stratified to match the age and sex distribution of all shelter users.[41] Because of limited sample size, many of our statistics have wide CIs, especially for subgroups of study participants. Medical history and medication use were determined on the basis of self-report. Overreporting is a concern for relatively subjective conditions such as angina, and underreporting may have occurred due to recall error or lack of adequate health care and sufficient diagnostic evaluation. Practical constraints prevented us from measuring blood pressure on multiple occasions or obtaining repeated or fasting biological specimens. The use of blood pressure readings from a single encounter may have led us to slightly overestimate the prevalence of hypertension, because elevated blood pressure should be detected on at least 3 separate occasions before hypertension is diagnosed.[22] However, our use of the average of 4 blood pressure measurements from each subject may have ameliorated this effect to some extent. Relatively few of our subjects were women, limiting our ability to draw conclusions about this important subgroup of homeless people. Finally, the generalizability of our findings to homeless adults in other cities needs to be assessed through future research.

In conclusion, treatment of cardiovascular risk factors is suboptimal among homeless adults in Toronto. The fact that this situation exists despite Canada's system of universal health insurance indicates that there are many barriers to appropriate health care for this population other than lack of health insurance. More than half of all homeless people in the United States do not have health insurance,[5] and this additional obstacle may result in even worse cardiovascular risk profiles than observed in our subjects. This study highlights several aspects of medical care for the homeless population that may be improved. Healthcare providers need to be aware of the numerous factors that potentially contribute to high mortality rates from CVD in these individuals. Interventions such as provision of primary health care, cardiovascular risk stratification, access to appropriate prescription medications, smoking cessation programs, and treatment of alcohol and cocaine abuse are clearly needed in this disadvantaged population.

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