## ORIGINAL RESEARCH

# Effect of a Housing Intervention on Selected Cardiovascular Risk Factors Among Homeless Adults With Mental Illness: 24-Month Follow-Up of a Randomized Controlled Trial

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**BACKGROUND:** Cardiovascular disease is a leading cause of mortality among people experiencing homelessness. This study investigated whether housing intervention affects cardiovascular disease risk factors among homeless adults with mental illnesses over a 24-month period.

**METHODS AND RESULTS:** We conducted a randomized controlled trial of a Housing First intervention that provided community-based scattered-site housing and support services. Five hundred seventy-five participants were randomized to the intervention (n=301) or treatment as usual (TAU) (n=274). Analyses were performed according to the intention-to-treat principle using generalized estimating equations. There were no differences in change over 24 months between the 2 groups for blood pressure, tobacco, and cocaine/crack use. However, the intervention had an impact on reducing the number of days of alcohol intoxication by 1.58 days compared with TAU (95% CI, −2.88 to −0.27, P=0.0018). Over the 24-month period, both the intervention and TAU groups had significant reductions in tobacco and cocaine use.

**CONCLUSIONS:** The intervention, compared with TAU, did not result in greater improvements in many of the selected cardiovascular risk factors. Since the study took place in a service-rich city with a range of pre-existing supportive services and universal health insurance, the high level of usual services available to the TAU group may have contributed to reductions in their cardiovascular disease risk factors. Further research is needed to develop interventions to reduce risk factors of cardiovascular disease among people experiencing homelessness and mental illness beyond existing treatments.

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**Key Words:** cardiovascular disease ■ cardiovascular risk factors ■ risk factors

It is estimated that >235 000 Canadians experience homelessness each year[1] and 552 830 Americans experience homelessness in a single night.[2] These numbers do not account for the hidden homeless who have extremely insecure housing and transition in and out of homelessness on a regular basis. A Canadian national report estimates that up to 80% of people experiencing homelessness are hidden homeless, with women and youth overrepresented in the hidden homeless population because they are less likely to make use of shelter services.[3] Housing is an important social determinant of health,[4,5] and homeless individuals face substantial barriers impairing their access to health care and significantly higher risk of premature mortality

## CLINICAL PERSPECTIVE

### What Is New?

- Housing First is growing in popularity as an intervention for homeless individuals, and this is one of the first randomized controlled trial studies to investigate its impact on cardiovascular disease risk in the homeless population with mental disorders.
- The intervention did not have a significant effect on the cardiovascular risk factors including blood pressure, smoking, and cocaine use, but showed some evidence of reducing alcohol addiction severity.

### What Are the Clinical Implications?

- Stable housing for homeless individuals may not be sufficient to reduce the high level of cardiovascular disease risk in this subpopulation.
- Stable housing is necessary to improve the health of people experiencing homelessness; however, it is not sufficient to reduce the high level of cardiovascular risk in this subpopulation.
- Interventions should be developed that can augment or complement the provision of housing and supports in order to improve the cardiovascular risk profile of people experiencing homelessness.

### Nonstandard Abbreviations and Acronyms

| | |
|---|---|
| **ACT** | assertive community treatment |
| **GEE** | generalized estimating equation |
| **TAU** | treatment as usual |

compared with the general population.[3] Numerous studies have documented that cardiovascular disease (CVD) is one of the leading causes of mortality among people experiencing homelessness.[4–13] Among homeless adults in Philadelphia, CVD was the second leading cause of death at 19%.[6] In an 11-year follow-up study of older homeless US Veterans, CVD was the most frequent cause of death at 33%.[12] Compared with the general population, homeless people have a significantly heightened risk of CVD mortality: in a 10-year follow-up study of mortality among homeless people in Finland, homeless individuals had an age-adjusted hazard ratio of 2.51 (95% CI, 1.67–3.77) for CVD mortality compared with the housed control group.[13] In a nationally representative 11-year follow-up study of homeless and marginally housed people in Canada, age-standardized mortality rate for cardiovascular diseases was 61% to 71% higher compared with the general population, and 63% to 80% higher for deaths from ischemic heart disease compared with the general population.[9] A 15-year follow-up study in Boston has shown that the relative risk of mortality caused by heart disease is particularly elevated among homeless men age 25 to 44 years, with 5.1 times higher mortality than the general population, and age 45 to 64 years, with 3.5 times higher mortality. A similar pattern was observed among homeless women.[4]

The high rate of CVD in homeless populations is attributable to a number of traditional and nontraditional risk factors. One such example would be the prevalence of hypertension among homeless individuals, which is similar to or slightly higher than in the general population,[14–16] since blood pressure is often poorly controlled among people experiencing homelessness. Tobacco use is another major contributor to CVD risk, as 68% to 81% of homeless individuals are current smokers.[14,17–21] The prevalence of current smoking among homeless adults in the United States is 3.5 times higher than in the US general population.[17]

Traditional risk factors for CVD such as hypertension and smoking accounted for in the Framingham equations do not capture the total burden of CVD risk factors among homeless persons, for whom heavy alcohol use[10] and cocaine use may have substantial effect on risk.[22,23] Heavy drinking has been linked to CVDs including congestive heart failure, left-ventricular dysfunction, and cardiomyopathy.[24–27] The prevalence of heavy drinking and alcohol dependence is higher in the homeless population compared with the general population.[28–30] Cocaine use has been linked to a variety of cardiovascular complications, including myocardial ischemia and infarction,[31] left ventricular hypertrophy,[32] cardiac dysrhythmias, and increased risk of bacterial endocarditis.[33] Cocaine use is common among homeless individuals: in a random sample of 202 homeless persons in Toronto, Canada, cocaine use in the past 12 months was reported in 29% of subjects (95% CI, 23-36%)[16]; and in a 15-year cohort study of homeless mortality (n=28 033),[4] 16.8% of the 1302 deaths were drug overdoses, where cocaine contributed to 37% of these deaths.

Individuals with severe mental illness (ie, schizophrenia, bipolar disorder, and depression) are at higher risk of CVD, have worse prognosis of CVD progression, and have increased risk of CVD-related mortality.[34,35] People with serious mental illness are disproportionately overrepresented in the homelessness population,[3,29] and the dual impact of homelessness and severe mental illness on CVD may be direct (eg, adverse effects of psychotropic medications or inadequate clinical monitoring[36]), or indirect (eg, mediated by factors such as food security/healthy diet[37]). Given the unique risk factors of homeless people with mental illness, evaluation of

interventions aimed at reducing the CVD risk in this population is required.

## Study Aims and Research Question

Housing First is an intervention for homeless individuals with mental illness that provides scattered-site housing using rent supplements combined with support services. Community-based scattered-site housing includes housing of participant's choice, often in private-market apartment buildings, rather than congregate settings purpose-built for this population.

Mental illnesses can exacerbate problems associated with homelessness and CVD, and a body of epidemiological data show that people with severe mental illness, including schizophrenia, bipolar disorder, and major depressive disorder, as a group, have an increased risk of developing CVD, compared with the general population (adjusted hazard ratio, 1.54; 95% CI, 1.30–1.82, $P<0.0001$).[38] However, it is currently unknown whether ending homelessness for people with mental illness results in changes in their cardiovascular risk factors. No previous randomized trials of Housing First or other housing interventions for homeless individuals with mental illnesses have examined their effect on major risk factors for CVD.

The At Home/Chez Soi study was a randomized controlled trial of Housing First for homeless adults with mental illness that was conducted in 5 Canadian cities. Evidence from this study has shown that the Housing First intervention is highly effective in improving housing stability.[39–41] The aim of this analysis is to determine whether a Housing First intervention for homeless adults with mental illness had an effect on participants' selected CVD risk factors. In this article, we used secondary data from the Toronto site of the At Home/Chez Soi study to examine whether a Housing First intervention was associated with a reduction in systolic and diastolic blood pressure, tobacco use, alcohol use, and cocaine use over a 24-month period after randomization. Please note that CVD risk factor data were only collected at the Toronto site of the study.

## METHODS

Data collected in the study are sensitive in nature, and access to the data set may be available from the corresponding author upon request.

## Study Design: Recruitment, Eligibility, Randomization, and Allocation for Randomized Controlled Trial

The At Home/Chez Soi study was an unblinded randomized controlled trial of a Housing First intervention.

The present study is a secondary analysis of the randomized controlled trial data. The target population for this study was homeless adults who had serious mental illness and who resided in the Toronto area. To be eligible for participation, respondents were required to be at least 18 years of age, absolutely homeless or precariously housed, and have a serious mental disorder. The presence of a serious mental disorder was established at the time of screening for study entry and was defined by a documented prior diagnosis or a Mini-International Neuropsychiatric Interview (MINI) diagnosis made at study entry of at least 1 of the following Axis I diagnoses considered eligible for this study: (1) major depressive episode; (2) manic or hypomanic episode; (3) mood disorder with psychotic features; (4) panic disorder; (5) posttraumatic stress disorder; and (6) psychotic disorder. Participants were recruited starting from October 2009 to July 2011 and were followed for 2 years after randomization. A total of 575 participants were randomized into either the intervention group (n=301) or treatment as usual (TAU) group (n=274) (Figure 1). Follow-up data for CVD risk factors were collected every 6 or 12 months over the 24-month period.

Participants randomized to receive the intervention were provided with housing and support services. Scattered-site housing was provided using rent supplements. Participants identified as high needs received housing with support from an assertive community treatment (ACT) team, and those with moderate needs received housing with intensive case management. The criteria for establishing need level included community functioning, mental disorder diagnosis, comorbid conditions, prior hospitalizations and incarcerations, as well as the Multnomah Community Ability Scale and are detailed in our study protocol.[42] The ACT and intensive case management treatment/support modalities within the trial have been detailed elsewhere.[39–41] Intervention participants had access to an onsite primary care clinic, to better coordinate their overall health needs, although CVD reduction was not a specific intervention target.

Participants randomized to TAU were not provided with any active intervention or support from the trial, but were able to access existing housing, health, and support services in the city of Toronto. Toronto has a rich network of services that participants in the TAU group have access to; these have been described in previous analyses of the trial.[39,40] Participants in both the intervention group and TAU groups had access to services including substance use withdrawal management services, residential treatment services, and ambulatory services across Toronto. Participants in the intervention group had access to case management to facilitate connection to such services, but no specific substance use services were offered through the
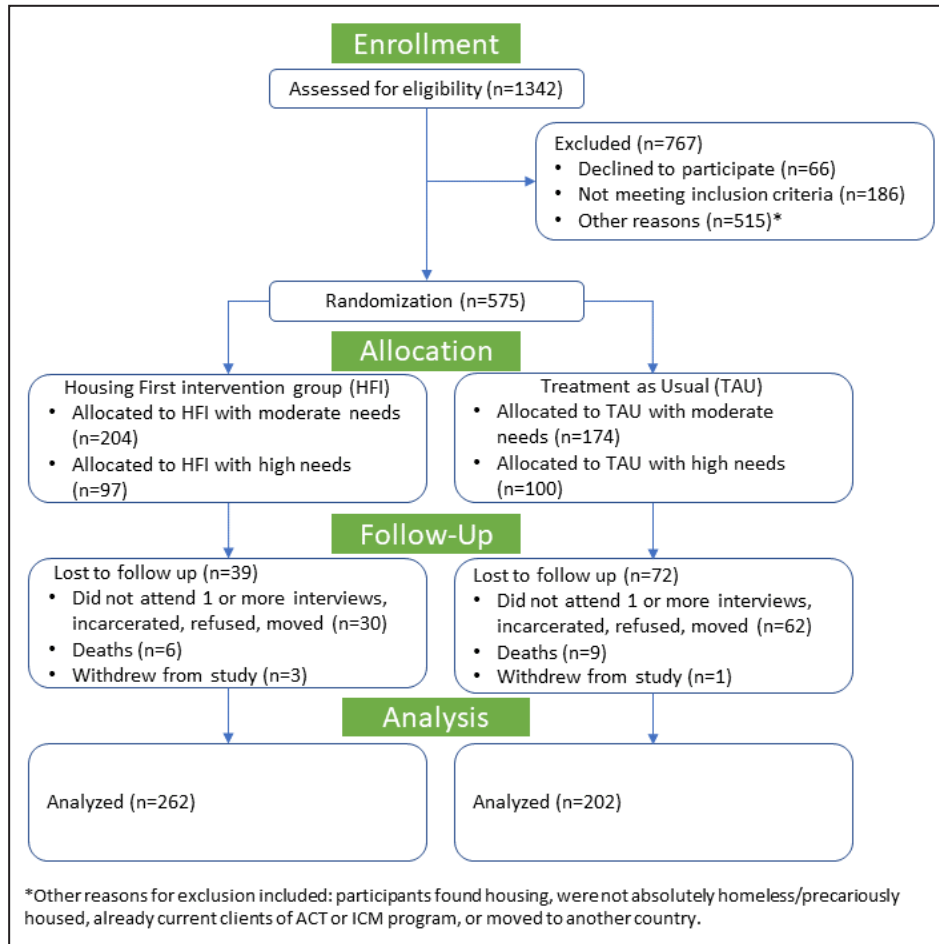
**Figure.** **A Consolidated Standards of Reporting Trials flow chart showing the process of enrollment, allocation, follow-up, and analysis of study participants.**
*Other reasons for exclusion included: participants found housing, were not absolutely homeless/ precariously housed, already current clients of ACT or ICM program, or moved to another country. ACT indicates assertive community treatment; HFI, Housing First intervention; TAU, treatment as usual; and ICM, intensive case management.

intervention. Since Housing First is predicated on the harm-reduction principle, participants were free to turn down substance use services with no consequences.

The study was approved by the Research Ethics Board of St. Michael's Hospital in Toronto and was registered with the International Standard Randomized Control Trial Number Register (ISRCTN42520374). Written consent was obtained from all study participants.

## Outcomes: CVD Risk Factors

We considered the following modifiable risk factors of CVD as outcomes in our study:

Blood pressure: these were based on 3 measurements (taken at baseline, 12, and 24 months). To measure systolic and diastolic blood pressure, an automated cuff-style upper-arm portable blood pressure monitor (A&D UA-767) was used, with its measurements validated in a prior study.[43] At each time point

(ie, baseline, 12, and 24 months), we measured 2 times in each arm, and the mean systolic and diastolic pressures were used for the analysis.

Tobacco use: participants were asked (at baseline, 12, and 24 months) if they currently smoked daily, occasionally, or not at all. They were considered to be a current smoker if they answered daily or occasionally.

Number of days consumed alcohol to intoxication: participants were asked (at baseline, 6, 12, 18, and 24 months) the number of days they used alcohol to intoxication in the past 30 days. The number of days drinking to intoxication in the past month is a question on the Addiction Severity Index used to evaluate alcohol addiction severity,[44] and a commonly used outcome in prior studies involving the homeless population.[45,46]

Cocaine/crack use: Participants were asked (at baseline, 6, 12, 18, and 24 months) if they used crack

and/or cocaine in the past 30 days. They were considered a user if they answered yes to either question.

## Statistical Analysis

All analyses were performed on an intention-to-treat basis. We modeled the 5 outcomes using separate multivariable generalized estimating equations (GEE). Exchangeable correlation structure was used for all GEE models to account for repeated measures over time from the same participant. We used linear GEEs for continuous outcomes (systolic blood pressure, diastolic blood pressure, and days of alcohol intoxication) and logistic GEEs for binary outcomes (tobacco use and cocaine use). All GEE models were fitted with the same covariates: treatment group (intervention vs. TAU), time (baseline, 6, 12, 18, and 24 months depending on when the outcome was measured), and an interaction between treatment and time. TAU and baseline were used as reference categories. All statistical tests were 2-sided. R (version 3.5.0) was used for all data analysis.

**Table 1.  Sample Characteristics at Baseline**

| | | All | Treatment as Usual | Housing First |
|---|---|---|---|---|
| Demographics | Levels | N (%) | N (%) | N (%) |
| Sex | Male | 394 (68.5) | 192 (70.1) | 202 (67.1) |
| | Female | 171 (29.7) | 73 (26.6) | 98 (32.6) |
| | Other | 10 (1.7) | 9 (3.3) | 1 (0.3) |
| Age group (y) | <25 | 72 (12.5) | 31 (11.3) | 41 (13.6) |
| | 25–39 | 200 (34.8) | 92 (33.6) | 108 (35.9) |
| | 40–49 | 182 (31.7) | 86 (31.4) | 96 (31.9) |
| | 50–64 | 112 (19.5) | 59 (21.5) | 53 (17.6) |
| | 65+ | 9 (1.6) | 6 (2.2) | 3 (1.0) |
| Ethnicity | Ethno-racial | 338 (58.8) | 156 (56.9) | 182 (60.5) |
| | Indigenous | 28 (4.9) | 11 (4.0) | 17 (5.7) |
| | Non–ethno-racial | 209 (36.4) | 107 (39.1) | 102 (33.9) |
| Birthplace | Born outside Canada | 250 (45.5) | 117 (45.5) | 133 (45.5) |
| | Born Inside Canada | 299 (54.5) | 140 (54.5) | 159 (54.5) |
| Marital status | Married/partner | 19 (3.5) | 9 (3.5) | 10 (3.5) |
| | Separated/widow/divorced | 148 (27.1) | 73 (28.4) | 75 (25.9) |
| | Single, never married | 380 (69.5) | 175 (68.1) | 205 (70.7) |
| Education level | Grade 8 or less | 57 (10.4) | 22 (8.6) | 35 (12.0) |
| | Incomplete high school | 205 (37.4) | 93 (36.5) | 112 (38.2) |
| | High school or higher | 286 (52.2) | 140 (54.9) | 146 (49.8) |
| Total lifetime duration of homelessness | <1 y | 120 (22.3) | 52 (20.7) | 68 (23.7) |
| | 1–3 y | 130 (24.2) | 61 (24.3) | 69 (24.0) |
| | 3 + y | 288 (53.5) | 138 (55.0) | 150 (52.3) |
| Need level | High needs | 197 (34.3) | 100 (36.5) | 97 (32.2) |
| | Moderate needs | 378 (65.7) | 174 (63.5) | 204 (67.8) |
| Manic episode or hypomanic episode* | No | 514 (89.4) | 251 (91.6) | 263 (87.4) |
| | Yes | 61 (10.6) | 23 (8.4) | 38 (12.6) |
| PTSD* | No | 441 (76.7) | 215 (78.5) | 226 (75.1) |
| | Yes | 134 (23.3) | 59 (21.5) | 75 (24.9) |
| Panic disorder* | No | 494 (85.9) | 237 (86.5) | 257 (85.4) |
| | Yes | 134 (14.1) | 37 (13.5) | 44 (14.6) |
| Mood disorder with psychotic features* | No | 456 (79.3) | 216 (78.8) | 240 (79.7) |
| | Yes | 119 (20.7) | 58 (21.2) | 61 (20.3) |
| Psychotic disorder* | No | 360 (62.6) | 170 (62.0) | 190 (63.1) |
| | Yes | 215 (37.4) | 104 (38.0) | 111 (36.9) |

*All serious mental illnesses were identified using the Mini-International Neuropsychiatric Interview. PTSD indicates post-traumatic stress syndrome.

**Table 2.  Linear Generalized Estimating Equation Model: Treatment as Usual and Baseline Were Used as Reference Points**

| Outcome | Timepoint | Estimate | P Value | 95% CI | Treatment as Usual Sample Means and SD | Housing First Intervention Sample Means and SD |
|---|---|---|---|---|---|---|
| Systolic blood pressure | Baseline | | | | 121.37 (SD=16.11) (n=242) | 121.86 (SD=19.34) (n=259) |
| | 12 Mo | −3.74 | 0.022 | −6.93 to −0.54 | 125.35 (SD=17.70) (n=152) | 121.87 (SD=18.15) (n=183) |
| | 24 Mo | −0.99 | 0.610 | −4.78 to 2.81 | 124.02 (SD=17.22) (n=103) | 122.59 (SD=17.70) (n=151) |
| Diastolic blood pressure | Baseline | | | | 79.28 (SD=11.60) (n=242) | 80.39 (SD=12.02) (n=259) |
| | 12 Mo | −1.73 | 0.167 | −4.19 to 0.72 | 81.74 (SD=12.76) (n=152) | 81.26 (SD=12.09) (n=183) |
| | 24 Mo | −0.10 | 0.943 | −2.96 to 2.75 | 81.67 (SD=12.64) (n=103) | 82.72 (SD=11.49) (n=151) |
| In the past 30 days, how many days of alcohol to intoxication | Baseline | | | | 2.89 (SD=6.76) (n=255) | 2.99 (SD=7.06) (n=293) |
| | 6 Mo | −1.22 | 0.042 | −2.39 to −0.05 | 3.52 (SD=8.04) (n=207) | 2.29 (SD=6.29) (n=258) |
| | 12 Mo | −1.01 | 0.095 | −2.19 to 0.17 | 3.41 (SD=8.07) (n=191) | 2.21 (SD=6.32) (n=263) |
| | 18 Mo | −0.67 | 0.243 | −1.81 to 0.46 | 2.80 (SD=7.21) (n=186) | 2.01 (SD=5.91) (n=246) |
| | 24 Mo | −1.58 | 0.018 | −2.88 to −0.27 | 3.52 (SD=8.03) (n=196) | 1.78 (SD=5.59) (n=256) |

P values for difference in change over time between treatment as usual and intervention groups.

## RESULTS

The majority of study participants were male (68.5%), had been homeless for 3 or more years (53.5%), and identified as a member of an ethno-racial group (58.8%). The sociodemographic characteristics at baseline are presented in Table 1.

To compare the change over time in the intervention versus TAU group for each outcome, we present the treatment by time interaction coefficients for the linear GEE models in Table 2 and the ratio of odds ratios for the logistic GEE models in Table 3. A ratio of odds ratios of <1 indicates that the intervention odds over time decreased proportionally more (or increased proportionally less) compared with TAU odds over time, and a ratio of odds ratios >1 indicated that the intervention odds over time decreased proportionally less (or increased proportionally more) compared with TAU odds over time. To help contextualize the models and ease of interpretation, we also provide the sample mean along with standard deviation (Table 2) or prevalence rates (Table 3) of each outcome stratified by treatment group

and time. We performed sex-based stratified models for all analyses listed below, but no significant differences were found between sex-specific and overall models. Hence, only the overall models are presented here.

Changes in systolic blood pressure over 12 months were significantly different between the intervention and TAU group, but not over 24 months. Compared with TAU over a 12-month period, the mean systolic blood in the intervention group saw an additional reduction of 3.74 mm Hg (β: −3.74, P=0.022, 95% CI, −6.93 to −0.54). However, the difference in the change in systolic blood pressure from baseline to 24 months was not different between the 2 groups (ie, −0.99 mm Hg, 95% CI, −4.78 to 2.81).

Over the 24 months, the average number of days of drinking to intoxication in the past month increased by 0.63 days in the TAU group, and the number of days decreased by 1.21 in the intervention group. The treatment effect difference was −1.58 days (95% CI, −2.88 to −0.27, P=0.018). The observed reduction of 1.21 days through the intervention over a 24-month

**Table 3.  Logistic Generalized Estimating Equation Model: Treatment as Usual and Baseline Were Used as Reference Points**

| Outcome | Timepoint | ROR | P Value | 95% CI | Treatment as Usual Sample Prevalence | Housing First Intervention Sample Prevalence |
|---|---|---|---|---|---|---|
| Currently smoke | Baseline | | | | 74.71% (n=257) | 71.13% (n=291) |
| | 12 Mo | 1.02 | 0.902 | 0.79–1.31 | 69.96% (n=193) | 66.54% (n=260) |
| | 24 Mo | 1.01 | 0.912 | 0.78–1.32 | 71.05% (n=190) | 66.27% (n=252) |
| Used crack or cocaine in past 30 d | Baseline | | | | 22.57% (n=257) | 20.62% (n=291) |
| | 6 Mo | 0.89 | 0.562 | 0.59–1.33 | 23.79% (n=206) | 18.36% (n=256) |
| | 12 Mo | 0.90 | 0.615 | 0.58–1.37 | 19.47% (n=190) | 14.50% (n=262) |
| | 18 Mo | 1.11 | 0.643 | 0.71–1.73 | 21.67% (n=180) | 19.34% (n=243) |
| | 24 Mo | 0.80 | 0.380 | 0.49–1.31 | 17.86% (n=196) | 11.81% (n=254) |

P values for difference in change over time between treatment as usual and intervention groups.

period represents a small but clinically relevant difference.

There were no differences in change over time between intervention and TAU for smoking and cocaine use, but improvement was observed within both the intervention and TAU groups. At 24 months compared with baseline, the relative odds of being a smoker was reduced by 20% in the intervention group (odds ratio, 0.80, 95% CI, 0.67–0.95, $P$=0.012) and in the TAU group (odds ratio, 0.79, 95% CI, 0.65–0.96, $P$=0.018). Similarly, the odds of cocaine use from baseline to 24 months was reduced in both the intervention group (odds ratio 0.55; 95% CI, 0.39–0.76; $P$<0.01) and the TAU group (odds ratio 0.68; 95% CI, 0.47–0.98; $P$=0.04).

## DISCUSSION

Over a 24-month period, we did not see greater improvements in blood pressure, tobacco use, and cocaine use among homeless individuals who received the intervention compared with TAU, while limited evidence suggests that the intervention may reduce daily intoxication at a greater rate compared with TAU over 24 months. Despite a number of prior studies documenting differences in cardiovascular risk factors between homeless individuals and the general population,[14–17,28,47] evidence from our study does not support the hypothesis that an intervention that provides stable housing and mental health supports for homeless individuals with mental illness results in improvements in CVD risk factors over and above the effects of TAU. This finding is not unexpected, because CVD risk reduction has not been a specific target for intervention in the Housing First model.

No previous randomized controlled trials have examined the impact of a Housing First intervention on blood pressure and smoking outcomes compared with a TAU group. While systolic blood pressure at 12 months appeared to decrease for the intervention compared with TAU ($P$=0.02) in our study, this difference was no longer significant at 24 months. Given the inconsistent trend over time, we caution against interpreting the results here to indicate that the intervention can reduce systolic blood pressure.

Prior reviews of the impact of the Housing First intervention for homeless people with addictions noted the sparsity of evidence from randomized trials regarding the effect of housing on substance-use outcomes.[48,49] Our study contradicts evidence documenting potential effectiveness of a Housing First intervention to reduce cocaine use in the homeless adult population.[50] In a study of a housing and support program aimed at homeless adults (N=734), past-month use of cocaine was reduced for participants who were illicit drug users at baseline over a 12-month period: from 45% to 27% ($P$<0.001) for crack and 14% to 7% ($P$<0.01) for cocaine. However, this study did not have a control group, which makes it impossible to determine whether the observed improvements were the result of the Housing First intervention. In our study, while we observe improvements in the intervention group in past-month cocaine use from 20.6% at baseline to 11.8% at 24 months, the improvement was not significantly different from improvements found in the TAU group. Compared with a prior study[50] that did not find a change in problematic alcohol use from baseline to 12 months, our study suggests that Housing First may have a modest impact on alcohol use (ie, difference in treatment effect of 1.58 days at 24 months). However, a longer follow-up period of 24 months (rather than 12 months) may be necessary to observe a significant treatment effect.

Participants in the intervention group of our study received a range of supportive services (in addition to housing) based on their need including case management, family support and education, substance use services, psychiatric services, general medical practice services, employment and housing assistance, and additional services designed for ethno-racial participants.[42,51] However, in the context of a study based in Toronto, Canada, a service-rich city with a range of pre-existing supportive services for homeless individuals, services for individuals with mental illnesses, and universal health insurance, the high level of usual supportive services available to the TAU group may have contributed to reductions in CVD risk factors over time. It is possible that the intervention might have a relatively larger effect on CVD risk factors in a city with fewer services available to the TAU group. It is also important to note that despite the harm-reduction approach of Housing First (ie, participants are not required to be abstinent from drug and alcohol use, unlike many traditional housing programs), participants in the intervention group still achieved statistically significant reductions over time in tobacco, alcohol, and cocaine use over the 24 months (despite TAU also achieving similar levels of reductions). Lastly, while there may be indirect benefits of the intervention on CVD risk factors (eg, having stable housing may allow individuals to make healthier lifestyle choices), CVD risk reduction was not a direct target or objective of the intervention.

There are a number of limitations with the present analysis. First, as this is a secondary analysis of data from a randomized controlled trial, data collected on CVD risk factors are not as comprehensive as a typical study that was designed with the investigation of CVD risk factors in mind. For example, while opioid use has been linked to CVDs such as infective endocarditis,[52] the data collected did not allow us to analyze opioid use in a comprehensive manner. Second, interviewers

could not be blinded to the intervention or TAU status of participants. Lack of blinding of the interviewers could result in bias towards attributing better outcomes to individuals in the intervention group, for measures based on interviewer observation rather than self-report. However, measures used in this study were based on self-report and were not expected to be influenced by the lack of blinding of the interviewers. Third, smoking, alcohol, and cocaine use were assessed using self-reports, which can be subject to reporting, recall, and social desirability bias. Fourth, there was significant attrition in both the intervention and TAU groups, and this loss to follow-up could have influenced our findings. Fifth, since our study included only participants with serious mental illnesses, it was not possible to investigate whether the impact of Housing First on CVD outcomes was modified by mental health status. Sixth, it is unknown whether differences between the intervention and TAU groups (in the selected CVD risk factors) may emerge beyond the 24-month follow-up period. Lastly, the lack of a continuous measure of tobacco use prevented us from completing a more detailed analysis on changes in smoking behaviors (eg, participants may have reduced the number of cigarettes smoked per day but not quit).

In conclusion, in a randomized controlled trial of housing and supports for homeless adults with mental illness, the intervention did not have a significant effect on the cardiovascular risk factors of blood pressure, smoking, and cocaine use. There is evidence that Housing First may reduce the number of days of alcohol intoxication by a small amount compared with TAU (ie, difference in treatment effect of 1.58 days). Over the 24-month period, both the intervention and TAU groups had significant reductions in tobacco and cocaine use. These findings suggest that although stable housing is necessary to improve the health of people experiencing homelessness, it is not sufficient to reduce the high level of cardiovascular risk in this subpopulation. Further research is needed to develop interventions that can augment or complement the provision of housing and supports, in order to improve the cardiovascular risk profile of people experiencing homelessness.

## ARTICLE INFORMATION

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### Disclosures

None.

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