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ORIGINAL PAPER

Elevated Mortality and Associated Social Determinants of Health in a Community-Based Sample of People Living with HIV in Ontario, Canada: Findings from the Positive Spaces, Healthy Places (PSHP) Study

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Abstract

We examined social determinants of health associated with all-cause mortality among 602 people living with HIV/AIDS in Ontario, Canada. Mortality status was verified at 1-, 3-, and 5-year follow-up visits with information obtained from proxies (family members, partners, and friends), obituaries, and local AIDS memorial lists. Of the 454 people for whom mortality information was available, 53 individuals died yielding a crude mortality rate of 22.3 deaths per 1000 person-years, a rate substantially higher than the rate in the general population (6.8 per 1000 population). Experiencing both homelessness and incarceration independently predicted high risk of mortality among men who have sex with men (MSM) while suboptimal self-rated general health at previous visit predicted higher greater risk of mortality in both MSM and women and heterosexual men. Homelessness and incarceration may contribute to HIV disease progression and mortality. Intensive case management that increases retention in care and facilitates linkage to housing services may help to reduce excess deaths among people with HIV.

Keywords Social determinants of health · Mortality · HIV · Homelessness · Incarceration

Introduction

In 2014, an estimated 75,500 people in Canada were living with HIV [1, 2]. Due to advances in antiretroviral therapy (ART), the total number of deaths due to HIV infection declined by half between 1997 and 2011 and 5-year survival rates among those diagnosed with AIDS increased from 7% in 1981–1986 to 65% in 1997–2012 [2]. In the United States and Canada, although the life expectancy of people living with HIV on ART has increased significantly, it still lags

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A complete list of members of The Positive Spaces Healthy Places Study Team appears in the Acknowledgements.

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behind the life expectancy of HIV-negative people by up to 13 years [3, 4].

Social determinants of health (SDOH) are the economic and social environments that shape the health of individuals and communities as a whole and play a major role in health disparities and health outcomes [5]. HIV-related outcomes, including mortality, are influenced by both individual level factors and social-structural level factors [6]. Studies that examined mortality in people with HIV have identified a number of social and structural factors that increase the risk of premature death in certain groups. For example, Anema et al. found that, among 254 HIV-positive residents of British Columbia who were on ART and injection drug users, those who were food insecure were twice as likely to die than those who were food secure [7]. Another Canadian study among 548 individuals on ART found that Indigenous participants were at higher risk of dying than members of several other ethnic groups [8]. Two longitudinal studies from the U.S. also found a link between low socioeconomic status and risk of mortality after adjusting for ART status. McMahon and colleagues followed 878 individuals living with HIV for 10 years and found a significant association between low income and increased mortality rate [9]. Hays et al., who followed a cohort of 2864 HIV-positive adults for 5 years, found that those with no accumulated financial assets and those with less than a high school education had an 81 and 52% greater risk of death, respectively, than their counterparts after adjusting for demographic and clinical variables, health insurance coverage, and antiretroviral treatment [10]. Depression is also significantly associated with a higher risk of AIDS-related mortality after controlling for clinical, substance use and sociodemographic factors [11].

A growing body of literature has also shown a link between housing and survival in people living with HIV. In a cohort of 6558 people diagnosed with AIDS between 1996 and 2006 who were followed for five-years, Schwarcz et al. found that those who were homeless at diagnosis had a 20% greater risk of dying than those who were not homeless [12]. They further found that, among people who were homeless at diagnosis, those who received supporting housing had a lower risk of mortality than those who did not, after adjusting for demographic and clinical variables. In a study of people diagnosed with HIV and AIDS between 2002 and 2006, the 5-year survival rate was worse for people who were homeless at diagnosis than for those who were housed [13]. Lack of appropriate housing has also been linked with lower rates of access to HIV care, adherence to ART and optimal HIV treatment—all of which may eventually contribute to mortality [14, 15].

Research in the general population has established a link between incarceration and premature mortality. Several studies have reported that former prisoners were more likely to die than other people of similar age, sex, and race in the first 2 years after release and the risk of death was particularly high in the first 2 weeks after release [16–20]. A large retrospective cohort study found that people who had previously been incarcerated had lower life expectancy (4.2 years less for men and 10.6 years less for women) than those who had not [20]. These studies also found HIV to be one of most common causes of death and the leading cause of excess mortality [21]. Although the direct association between incarceration and increased risk of mortality is not clear, studies have found that people with a history of incarceration experienced faster HIV disease progression than those who have not been incarcerated [22]. People living with HIV who have been in prison are also substantially less likely to be engaged and retained in care after their release [23]. Faster HIV disease progression and suboptimal engagement and retention in care may contribute to premature mortality.

The World Health Organization concludes that while access to health care is a major determinants of health, the high burden of illness contributing to premature loss of life arise in large part due to the conditions in which people grow, live, and work and these conditions are, in turn, influenced by economic, social, and political forces [24]. Social and economic conditions can have a more prominent effect on the health of people living with HIV as they are disproportionately affected by social and economic inequalities including higher unemployment and poverty, incarceration, homelessness or housing instability, social isolation, mental health and addiction, and food insecurity than the general population [25]. With the advance in antiretroviral therapy, non-medical factors that impact health outcomes have gained importance. It is important to identify and monitor proximal and distal factors that could be addressed to improve health outcomes and survival among people with HIV [5]. In Canada, the influence of social determinants of health on survival among people living with HIV is not well understood. Using longitudinal data collected through the CIHR-funded Positive Spaces, Healthy Places (PSHP) study, we examined socio-demographic and health correlates of all-cause mortality in a sample of people living with HIV in Ontario, Canada.

Methods

Study Participants

This study involves secondary data analysis from the Positive Spaces, Healthy Places (PSHP) study, a 5-year longitudinal observational cohort of 602 individuals living with HIV in Ontario. The main objective of PSHP study was to explore the housing needs of people living with HIV and assess the impact of housing on health and health-related quality of life. Details of the study design are reported elsewhere [26,

27]. To ensure the sample was as representative as possible, participants were recruited using a range of health and social service access points including: shelters, agencies serving women, families and youth, Indigenous organizations, transitional housing providers, and supportive housing agencies. Efforts were made to include hard-to-reach populations such as people who are homeless or unstably housed (i.e., individuals living in shelters, hotels, motels or couch surfing). Individuals were eligible to participate if they were 18 years or older, residents of Ontario and were diagnosed with HIV. All participants provided written consent. The study was approved by the Research Ethics Boards of the University of Toronto and McMaster University.

Data Collection

Data were collected through Peer Research Associate (PRA) administered face-to-face interviews using a structured quantitative questionnaire. A total of four interviews were conducted at baseline (April 2006–September 2006), 1-year follow-up (April 2007–December 2007), 3-year follow-up (March 2009–Dec 2009), and 5-year follow-up (June 2011–October 2012). Of the 602 participants enrolled at baseline, 509 (85%) completed 1-year follow-up, 442 (74%) completed the three-year follow-up, and 401 (69%) completed the 5-year follow-up interviews (Fig. 1). Interviews were conducted at community-based agencies including AIDS service organizations based on participants' preference. Participants were compensated $40 per interview.

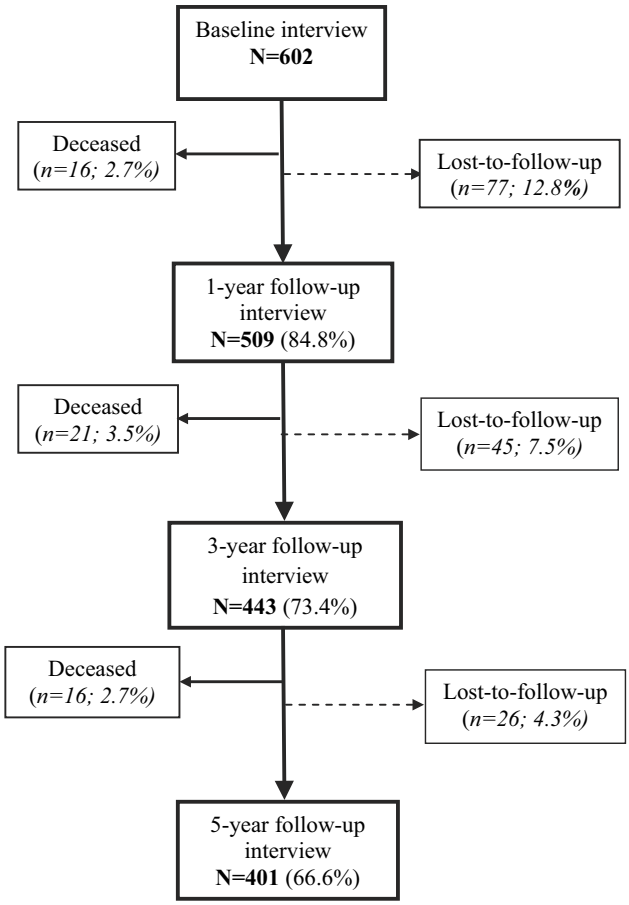

Fig. 1 Study flow diagram, PSHP study

Measures

Mortality

Our primary outcome of interest was death due to any cause. Several methods were used to assess deaths. When a participant failed to complete a follow-up interview, PRAs contacted alternate contacts (families, partners and friends) to determine whether the participant was alive or had died. PRAs also examined obituaries (both online and print), funeral home death notices, and local AIDS memorial lists.

Predictor Variables

Data collected included age, gender, sexual orientation, education, employment status, income and housing status. Alcohol and illicit drug use in the past 12 months were assessed using the Alcohol Use Disorder Identification Test and the Drug Abuse Screening Test, respectively [28, 29]. Depressive symptoms were assessed using The Center for Epidemiological Studies Depression-Revised scale [30]. Data on HIV-related disease variables (time since HIV diagnosis, antiretroviral therapy status, and diagnosis of AIDS) were self-reported through interviews.

Health-related quality of life was assessed using the Medical Outcomes Study HIV Health Survey (MOS-HIV) [31]. The MOS-HIV has 10 subscales and two aggregate measures: physical health summary (PHS) and mental health summary (MHS). Scores for the subscale as well as the two summary measures were computed following the developers' instructions and ranged from 0 (worst) to 100 (best) [32].

Statistical Analysis

Of the 602 individuals enrolled in the study, 454 participants who either completed the five-year follow-up (n = 401) or were confirmed as deceased (n = 53) were eligible for analyses (Fig. 1). One hundred forty-eight participants who were either lost to follow-up or whose death status could not be determined were excluded from final analyses. We compared baseline demographics, socioeconomic status, housing, substance use, psychosocial and HIV disease characteristics between participants who died versus those who completed

the 5-year follow-up interview using *t* tests or Chi square tests as appropriate. We calculated standardized mortality ratio (SMR) as the number of observed deaths divided by age-adjusted expected number of deaths. Expected number of deaths were derived using age-specific mortality rates observed in the general population of Ontario in 2012. Cox proportional hazards models were used to identify variables associated with mortality. Variables that were associated with mortality (p-values < 0.10) and changed unadjusted effect estimates by more than 10% were retained in the final multivariable regression model. A time-lagged multivariable cox proportional hazards model was fitted with mortality status at a follow-up visit as the dependent variable and sociodemographic, housing and clinical variables at the previous visit as predictors. When two predictor variables are strongly correlated, we either combined them (e.g., history of incarceration and history of homelessness) into one variable or removed one of them (e.g., age and years since HIV diagnosis) from multivariable regression models. Hazards Ratios (HR) and 95% confidence intervals (CI) were estimated for all models. We verified the proportional hazard assumption by plotting Schoenfeld residuals against the time scale. All analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC) with a two-tailed p value < 0.05 indicating statistically significance.

Results

Baseline characteristics of the final sample included mean age 43 years, 72% male, 74% Caucasian, 78% unemployed, 68% with income < $12,000/year, 76% on antiretroviral treatment, 42% with a history of homelessness, and 31% with a history of incarceration (Table 1). Of the 454 participants included in final analyses, 53 (12%) died during the follow-up period yielding a crude mortality ratio of 23.3 deaths per 1000 persons. Individuals who died during the follow-up period were more likely to have less than high school education (36 vs. 20%, $p = 0.010$), be unemployed (89 vs. 77%, $p = 0.045$), report a history of homelessness (57 vs. 39%, $p = 0.017$) or incarceration (58 vs. 28%, $p < 0.001$), and report harmful drug use (42 vs. 25%, $p = 0.001$) than those who were alive at 5-year follow-up. In terms of location, participants who died were less likely to reside in the Greater Toronto Area (42 vs. 59%, $p = 0.047$) than those who were alive. Participants who died were more likely to rate their general health as "fair" or "poor" than those who were alive at the 5-year follow-up (47 vs. 27%, $p < 0.001$) at baseline. Although participants who died were more likely to be diagnosed with AIDS (60 vs. 49%, $p = 0.124$) and be on antiretroviral treatment (83 vs. 75%, $p = 0.203$) at baseline, these differences were not significant statistically.

In unadjusted cross-sectional analyses, predictors of mortality varied by gender and sexual orientation. Among men who have sex with men (MSM), baseline variables significantly associated ($p < 0.05$) with increased risk of death included history of incarceration, history of homelessness, harmful drug use, history of hepatitis C virus (HCV) infection, and poor self-rated general health (Table 2). Among women and heterosexual men, Caucasian ethnicity, history of incarceration, and poor self-rated general health significantly predicted ($p < 0.05$) increased risk of mortality in unadjusted analyses (Table 3).

In time-updated unadjusted proportional hazards models, predictors of increased risk of mortality among MSM were history of incarceration, history of homelessness, harmful non-medicinal drug use, elevated level of depressive symptoms, history of HCV infection, and poor self-rated general health status. On the other hand, older age at baseline, male gender, Caucasian ethnicity, history of incarceration, harmful drug use, and sub-optimal general health status predicted higher risk of mortality among women and heterosexual men. We found no significant association between HIV disease variables (i.e., diagnosis of AIDS and antiretroviral treatment) and risk of mortality in MSM or in women and heterosexual men.

In multivariable regression, exposure to homelessness and incarceration (HR 2.13; 95% CI 1.04–4.39; $p = 0.040$) and suboptimal general health at the previous visit (HR 2.71; 95% CI 1.14–6.48; $p = 0.025$ for general health-rated as "good" and HR 5.09; 95% CI 2.14–12.09; $p < 0.001$ for general health-rated as "fair/poor") remained independent predictors of higher risk of mortality among MSM. Although an elevated risk of mortality was observed among MSM with harmful drug use, elevated level of depressive symptoms, and history of HCV, the associations did not reach statistical significance. Among women and heterosexual men, only sub-optimal general health at the previous visit (HR 4.06; 95% CI 1.44–11.47; $p = 0.008$ for general health-rated as "good" and HR 4.87; 95% CI 1.75–13.55; $p = 0.002$) for general health-rated as "fair/poor") independently predicted higher risk of mortality. The risk of mortality was marginally ($p = 0.091$) higher in heterosexual men than women and in participants who identified as Caucasian than non-Caucasian ethnicity. Participants who reported a history of homelessness and incarceration and had slightly higher risk of mortality (HR 1.88; 95% CI 0.82–4.30; $p = 0.134$), but the association did not reach statistical significance.

Discussion

The objective of this study was to identify whether social determinants of health were associated with all-cause mortality over a five-year period in a sample of adults living

Table 1 Baseline characteristics of PSHP study participants by mortality status at 5-year follow-up

Baseline characteristics	Mortality status at 5-year follow-up			Total sample (N = 602)	*P*
	Deceased (n = 53)	Alive (n = 401)	Lost to follow-up[§] (n = 148)		
Age in years[†]					0.081
20–39	9 (17%)	116 (29%)	52 (35%)	177 (29%)	
40–49	29 (55%)	177 (44%)	61 (41%)	267 (44%)	
50–70	14 (26%)	87 (22%)	24 (16%)	125 (21%)	
Gender[c]					**0.001**
Women	10 (19%)	116 (29%)	22 (15%)	148 (25%)	
Men who have sex with men (MSM)	29 (55%)	224 (56%)	106 (72%)	359 (59%)	
Men, heterosexual	14 (26%)	61 (15%)	20 (13%)	95 (16%)	
Highest education level[a]					**0.036**
High school diploma or higher	34 (64%)	320 (80%)	115 (78%)	469 (78%)	
Less than high school	19 (36%)	81 (20%)	33 (22%)	133 (22%)	
Race/ethnicity					0.243
White	44 (83%)	290 (72%)	107 (72%)	441 (72%)	
Other	9 (17%)	111 (28%)	41 (28%)	161 (28%)	
Employment status[a,c]					**0.010**
Unemployed/retired/on disability	47 (89%)	307 (77%)	127 (86%)	481 (80%)	
Working for pay	6 (11%)	94 (23%)	20 (14%)	120 (20%)	
Annual income[‡]					0.564
≥ $12,000	32 (64%)	265 (69%)	91 (61%)	388 (64%)	
< $12,000	18 (36%)	120 (31%)	50 (34%)	188 (31%)	
Geographic location[a,b,c]					**<0.001**
Greater Toronto Area	22 (42%)	238 (59%)	114 (77%)	374 (62%)	
Eastern/Northern Ontario	19 (36%)	97 (24%)	18 (12%)	134 (22%)	
Southwestern Ontario	12 (23%)	66 (17%)	16 (11%)	94 (16%)	
Ever incarcerated[a,b]					**<0.001**
Yes	31 (58%)	112 (28%)	46 (31%)	189 (31%)	
No	22 (42%)	289 (72%)	102 (69%)	413 (69%)	
Ever been homeless[a]					**0.046**
Yes	30 (57%)	158 (39%)	66 (45%)	254 (42%)	
No	23 (43%)	243 (61%)	82 (55%)	348 (58%)	
Alcohol use, past 12 months					0.527
None	13 (25%)	112 (28%)	41 (28%)	166 (28%)	
Non-harmful use (AUDIT < 8)	26 (49%)	214 (54%)	72 (49%)	312 (52%)	
Harmful use (AUDIT ≥ 8)	14 (26%)	74 (18%)	35 (24%)	123 (20%)	
Drug use, past 6 months[a,b]					**0.016**
None	16 (30%)	221 (55%)	76 (51%)	313 (52%)	
Non-harmful use (DAST < 6)	15 (28%)	79 (20%)	34 (26%)	128 (21%)	
Harmful use (DAST ≥ 6)	22 (42%)	101 (25%)	38 (26%)	161 (27%)	
Depressive symptoms[b]					**0.047**
CES-D ≥ 16	32 (60%)	196 (49%)	61 (41%)	289 (48%)	
CES-D < 16	21 (40%)	205 (51%)	87 (59%)	313 (52%)	
On antiretroviral therapy					0.081
Yes	44 (83%)	301 (75%)	101 (68%)	446 (74%)	
No	9 (17%)	100 (25%)	47 (32%)	156 (26%)	
Ever diagnosed with AIDS					0.221
Yes	32 (60%)	197 (49%)	69 (47%)	298 (50%)	
No	21 (40%)	204 (51%)	79 (53%)	304 (50%)	

Table 1 (continued)

Baseline characteristics	Mortality status at 5-year follow-up			Total sample (N = 602)	*P*
	Deceased (n = 53)	Alive (n = 401)	Lost to follow-up[§] (n = 148)		
Ever diagnosed with Hepatitis C[b,c]					**<0.001**
Yes	18 (34%)	88 (22%)	14 (9%)	120 (20%)	
No	35 (66%)	313 (78%)	134 (91%)	482 (80%)	
Years since HIV diagnosis					0.432
< 5	13 (25%)	95 (24%)	48 (32%)	156 (26%)	
6–10	10 (19%)	90 (22%)	29 (20%)	129 (21%)	
11–15	12 (23%)	100 (25%)	28 (19%)	140 (23%)	
16+	18 (34%)	116 (29%)	43 (29%)	177 (29%)	
Self-reported general health[a,b]					**0.006**
Excellent/very good	7 (13%)	145 (36%)	52 (35%)	204 (34%)	
Good	21 (40%)	147 (37%)	49 (33%)	217 (36%)	
Fair/poor	25 (47%)	109 (27%)	47 (32%)	181 (30%)	

Bold face indicates statistical significance ($p < 0.05$)

[§]Participants who were lost-to-follow-up are excluded from regression analyses

[†]Age missing for 33 participants

[‡]Income information missing for 26 individuals

[a]$p < 0.05$, deceased versus alive

[b]$p < 0.05$, deceased versus lost to follow-up

[c]$p < 0.05$, alive versus lost to follow-up

with HIV in Ontario, Canada. A total of 53 participants died yielding a crude mortality rate of 23 per 1000 person-years, a rate that is substantially higher than the crude mortality rate of 6.8 deaths per 1000 population observed in the general population [33]. We also found that predictors of mortality varied by gender and sexual orientation. In men who have sex with men, self-reported history of homelessness and incarceration and sub-optimal self-rated general health (rated as "Good" or "Fair/poor") were associated with increased risk of mortality, after adjusting for other confounder variables. Among women and heterosexual men, however, we found no significant association between a history of incarceration and homelessness and mortality. As observed in MSM, poor self-rated general health predicted greater risk of mortality in women and heterosexual men.

In the general population, previous research has linked current and past homelessness with excess mortality rate [34–37]. In people living with HIV, lower survival rates have been reported among those who were homeless at diagnosis compared to those who were housed and survival rates improved once supportive housing was provided [13]. HIV care may likely be interrupted or discontinued among those who are marginally housed or homeless due to the instability associated with homelessness. A longitudinal study that followed 485 HIV-positive individuals receiving care in a hospital found that being homeless at initial visit was associated with decreased odds of engagement and retention in care over a 24-month period [38]. In addition to homelessness, unstable and inadequate housing have also been linked with lower rates of access to HIV care, lower uptake of antiretroviral treatment, and suboptimal adherence to HIV treatment—all of which may eventually contribute to mortality [14, 15, 39]. Even in a universal health care system, homeless or marginally housed people have unmet health care needs and face barriers accessing appropriate medical care including loss of proof of insurance, lack of insurance benefits for drug coverage, and negative previous encounters with health care providers [40–43].

Evidence from the general population also shows that former prisoners are more likely to die than the general population in the first 2 years after release [16–21]. Incarceration acts as a catalyst for worsening health as it negatively impacts the health of individuals, families, and communities through the incarceration experience, worsening social conditions post-release and macro policy [44]. Among former prisoners with HIV infection, health care is often disrupted after release due to competing priorities for basic subsistence needs, untreated mental illness, relapse to substance use, and lapses in medical or social benefits leading to declining levels of engagement and retention in care, antiretroviral treatment adherence, and viral suppression [23, 45–47].

While studies that examined the impact of dual exposure of homelessness and incarceration on health and mortality are lacking, it is known that homelessness is common among

Table 2 Predictors of all-cause mortality among men who have sex with men: results from cox proportional hazards regression models

Predictor variable	Unadjusted estimates (baseline data)[a]			Unadjusted estimates (time-updated data)[b]			Adjusted estimates (time-updated data)[b]		
	HR	(95% CI)	*P*	HR	(95% CI)	*P*	HR	(95% CI)	*P*
Age at baseline (per 10 years)	1.38	(0.90, 2.13)	0.142	1.17	(0.78, 1.78)	0.447	–	–	–
Race/ethnicity (Caucasian)	0.83	(0.32, 2.17)	0.696	0.74	(0.29, 1.92)	0.536	–	–	–
Education (< high school)	2.25	(1.00, 5.09)	0.051	2.23	(0.98, 5.07)	0.055	1.57	(0.85, 2.89)	0.152
Annual income (< $12,000)	1.48	(0.68, 3.22)	0.325	1.04	(0.51, 2.12)	0.907	–	–	–
History of incarceration (yes)	3.55	(1.71, 7.37)	**0.001**	3.14	(1.51, 6.54)	**0.002**	–	–	–
History of homelessness (yes)	2.28	(1.10, 4.74)	**0.028**	2.17	(1.30, 3.65)	**0.003**	–	–	–
History of incarceration/homelessness[c]									
Neither (Ref)	–	–	–	–	–	–	1.00	–	–
Incarceration only	–	–	–	–	–	–	1.83	(0.81, 4.14)	0.148
Homelessness only	–	–	–	–	–	–	0.99	(0.39, 2.49)	0.981
Incarceration and Homelessness	–	–	–	–	–	–	2.13	(1.04, 4.39)	**0.040**
Harmful alcohol use (AUDIT ≥ 8)	1.20	(0.51, 2.80)	0.679	1.53	(0.78, 3.02)	0.216	–	–	–
Harmful drug use (DAST-20 ≥ 6)	2.26	(1.08, 4.73)	**0.031**	2.58	(1.30, 5.10)	**0.006**	1.44	(0.78, 2.63)	0.243
Depression (CES-D ≥ 16)	2.03	(0.94, 4.37)	0.070	2.49	(1.32, 4.69)	**0.005**	1.51	(0.86, 2.68)	0.155
On antiretroviral therapy (yes)	1.20	(0.46, 3.15)	0.707	0.92	(0.39, 2.20)	0.854	–	–	–
Diagnosed with AIDS (yes)	1.43	(0.68, 3.03)	0.351	1.40	(0.64, 3.04)	0.397	–	–	–
History of HCV infection (yes)	2.53	(1.15, 5.55)	**0.021**	3.12	(1.53, 6.35)	**0.002**	1.65	(0.90, 3.04)	0.107
Self-reported general health									
Excellent/very good (ref)	1.00	–	–						
Good	3.91	(1.28, 11.88)	**0.016**	3.32	(1.38, 8.01)	**0.007**	2.71	(1.14, 6.48)	**0.025**
Fair/poor	5.16	(1.64, 16.24)	**0.005**	7.02	(2.92, 16.84)	**<0.001**	5.09	(2.14, 12.09)	**<0.001**

Bold face indicates statistical significance ($p < 0.05$)

Variables that were significant/marginal association with mortality ($p < 0.10$) only were eligible to be included in the final multivariable regression model. The multivariable model is further adjusted for geographic region

HR hazards ratio, *AUDIT* alcohol use disorder identification test, *DAST* drug abuse screening test, *CES-D* center for epidemiological studies-depression scale, *HCV* hepatitis C virus infection

[a]N = 253

[b]N = 253 and 692 person-years

[c]Due to strong correlation between history of incarceration and history of homelessness, the two variables were combined into one variable for multivariable regression analyses

former prisoners and that a considerable proportion of the homeless population experience incarceration suggesting that one can be a precursor or an outcome of the other [48–51]. People affected by both homelessness and incarceration lack personal, social, and psychosocial resources as previous research has shown they are predominantly minority, undereducated, and have few job skills [52]. Furthermore, they face extra burden of health problems as they have high rates of mental illness and substance use disorders [52]. It is possible that extra burden of health problems coupled with lack of appropriate personal resources to maintain health as well as barriers to lack of available social resources may have contributed to progression of HIV disease and mortality among our study participants who experienced both homelessness and incarceration. It should be noted, however, that our participants were recruited predominantly through agencies that provide housing and other social services and hence, our sampling may artificially increased the statistical power of the association between mortality and homelessness and incarceration variables.

The data presented in this study should be interpreted in light of the following limitations. First, generalizability of our findings may be somewhat limited because our sample was recruited primarily through front-line AIDS service organizations that provide housing services. As such, participants were predominantly unemployed and living in poverty, often with marginal housing, and a history of incarceration and homelessness. Second, data on mortality were collected by contacting participants' alternate contacts (families, partners, and friends) and from public sources such as newspaper obituaries and AIDS memorial lists. Deaths are not confirmed by objective measures such as death certificates.

Table 3 Predictors of all-cause mortality among women and heterosexual men: Results from bivariable and multivariable cox hazards regression models

Predictor variable	Unadjusted estimates (baseline data)[a]			Unadjusted estimates (time-updated data)[b]			Adjusted estimates (time-updated data)[b]		
	HR	(95% CI)	*P*	HR	(95% CI)	*P*	HR	(95% CI)	*P*
Age at baseline (per 10 years)	1.30	(0.80, 2.12)	0.297	1.47	(1.04, 2.09)	**0.030**	1.21	(0.78, 1.87)	0.388
Gender (Men)	2.10	(0.93, 4.75)	0.074	2.67	(1.15, 6.25)	**0.022**	1.89	(0.91, 3.95)	0.091
Race/ethnicity (Caucasian)	3.48	(1.19, 10.18)	**0.023**	4.17	(1.30, 13.34)	**0.016**	2.78	(0.85, 9.06)	0.091
Education (< high school)	2.03	(0.91, 4.54)	0.086	1.56	(0.88, 2.79)	0.132	–	–	–
History of Incarceration (yes)	2.98	(1.21, 7.34)	**0.018**	3.39	(1.76, 6.54)	**0.010**	–	–	–
History of Homelessness (yes)	1.57	(0.65, 3.80)	0.313	1.56	(0.84, 2.92)	0.160	–	–	–
Incarceration/homelessness[c]									
Neither (Ref)	–	–	–	–	–	–	1.00	–	–
Incarceration only	–	–	–	–	–	–	1.38	(0.44, 4.36)	0.587
Homelessness only	–	–	–	–	–	–	0.85	(0.16, 4.56)	0.849
Incarceration and homelessness	–	–	–	–	–	–	1.88	(0.82, 4.30)	0.134
Harmful alcohol use (AUDIT ≥ 8)	1.66	(0.68, 4.02)	0.264	1.34	(0.67, 2.71)	0.413	–	–	–
Harmful drug use (DAST-20 ≥ 6)	1.43	(0.63, 3.25)	0.390	1.84	(1.04, 3.28)	**0.038**	1.12	(0.52, 2.41)	0.777
Depression (CES-D ≥ 16)	1.09	(0.49, 2.43)	0.837	1.43	(0.80, 2.56)	0.227	–	–	–
On antiretroviral therapy (yes)	2.12	(0.73, 6.20)	0.170	1.47	(0.68, 3.14)	0.326	–	–	–
Diagnosed with AIDS (yes)	1.82	(0.81, 4.11)	0.150	1.99	(0.91, 4.34)	0.084	1.46	(0.76, 2.82)	0.260
History of HCV infection (yes)	0.94	(0.40, 2.18)	0.883	1.83	(0.86, 3.86)	0.116	–	–	–
Self-reported general health									
Excellent/very good (ref)	1.00	–	–	1.00	–	–	1.00	–	–
Good	2.01	(0.52, 7.83)	0.312	4.66	(1.65, 13.16)	**0.006**	4.06	(1.44, 11.47)	**0.008**
Fair/poor	3.99	(1.14, 13.93)	**0.030**	6.49	(2.34, 18.05)	**<0.001**	4.87	(1.75, 13.55)	**0.002**

Bold face indicates statistical significance ($p < 0.05$)

Variables that were significant/marginal association with mortality ($p < 0.10$) only were eligible to be included in the final multivariable regression model. The multivariable model is further adjusted for geographic region

HR hazards ratio, *AUDIT* alcohol use disorder identification test, *DAST* drug abuse screening test, *CES-D* center for epidemiological studies-depression scale, *HCV* hepatitis C virus infection

[a]N = 201

[b]N = 201 and 555 person-years

[c]Due to strong correlation between history of incarceration and history of homelessness, the two variables were combined into one variable for multivariable regression analyses

As a result, our data may be prone to measurement error. Due to lack of information on cause of death, we were not able to determine whether death occurred due to HIV disease or other non-HIV related causes. Third, due to the study design, we were not able to determine temporal sequences between HIV diagnosis and some predictor variables (i.e., incarceration, homelessness, and HCV infection); therefore, it is possible that these events may have occurred prior to or after HIV infection. Fourth, it is also possible that loss-to-follow-up may have occurred in a non-random fashion and have introduced biases.

Despite these limitations, our data provide evidence that history of homelessness and incarceration may increase the risk of mortality in people living with HIV. People with HIV who are homeless or marginally housed, members of two marginalized groups, face multiple and complex challenges. HIV care may be disrupted due to competing priorities for basic subsistence needs including housing and employment. Intensive case management that facilitates linkage to HIV care and treatment and social services including affordable housing and employment opportunities are required.

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Compliance with Ethical Standards

Conflicts of interest All authors declare no conflicts of interest.

Ethical Approval The PSHP study has received approval from ethics review boards of the University of Toronto and McMaster University. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individuals included in the study.

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