

Mortality Among Unsheltered Homeless Adults in Boston, Massachusetts, 2000-2009

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IMPORTANCE Previous studies have shown high mortality rates among homeless people in general, but little is known about the patterns of mortality among "rough sleepers," the subgroup of unsheltered urban homeless people who avoid emergency shelters and primarily sleep outside.

OBJECTIVES To assess the mortality rates and causes of death for a cohort of unsheltered homeless adults from Boston, Massachusetts.

DESIGN, SETTING, AND PARTICIPANTS A 10-year prospective cohort study (2000-2009) of 445 unsheltered homeless adults in Boston, Massachusetts, who were seen during daytime street and overnight van clinical visits performed by the Boston Health Care for the Homeless Program's Street Team during 2000. Data used to describe the unsheltered homeless cohort and to document causes of death were gathered from clinical encounters, medical records, the National Death Index, and the Massachusetts Department of Public Health death occurrence files. The study data set was linked to the death occurrence files by using a probabilistic record linkage program to confirm the deaths. Data analysis was performed from May 1, 2015, to September 6, 2016.

EXPOSURE Being unsheltered in an urban setting.

MAIN OUTCOMES AND MEASURES Age-standardized all-cause and cause-specific mortality rates and age-stratified incident rate ratios that were calculated for the unsheltered adult cohort using 2 comparison groups: the nonhomeless Massachusetts adult population and an adult homeless cohort from Boston who slept primarily in shelters.

RESULTS Of 445 unsheltered adults in the study cohort, the mean (SD) age at enrollment was 44 (11.4) years, 299 participants (67.2%) were non-Hispanic white, and 72.4% were men. Among the 134 individuals who died, the mean (SD) age at death was 53 (11.4) years. The all-cause mortality rate for the unsheltered cohort was almost 10 times higher than that of the Massachusetts population (standardized mortality rate, 9.8; 95% CI, 8.2-11.5) and nearly 3 times higher than that of the adult homeless cohort (standardized mortality rate, 2.7; 95% CI, 2.3-3.2). Non-Hispanic black individuals had more than half the rate of death compared with non-Hispanic white individuals, with a rate ratio of 0.4 (95% CI, 0.2-0.7; $P < .001$). The most common causes of death were noncommunicable diseases (eg, cancer and heart disease), alcohol use disorder, and chronic liver disease.

CONCLUSIONS AND RELEVANCE Mortality rates for unsheltered homeless adults in this study were higher than those for the Massachusetts adult population and a sheltered adult homeless cohort with equivalent services. This study suggests that this distinct subpopulation of homeless people merits special attention to meet their unique clinical and psychosocial needs.

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- [+ Invited Commentary](#)
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A paucity of literature exists regarding the health status of unsheltered, urban homeless adults, also known as “rough sleepers.” These elusive, yet highly visible unsheltered individuals eschew organized shelters and choose to sleep on park benches, in back alleyways, in doorways, under bridges, near train stations, and in abandoned cars.

In the United States, the unsheltered population constitutes more than a third of the overall homeless population, with an estimated 192 875 people sleeping unsheltered on a single night in January 2017.¹ Most of these individuals were men 24 years or older of white or non-Hispanic race/ethnicity.¹ Despite their visibility, this population wanders across our urban landscapes, and data on these individuals are difficult to gather. Previous studies of mortality have focused on the homeless population who primarily sleep in shelters, and these studies have found higher rates of death in homeless populations compared with nonhomeless populations.²⁻⁹ Studies from the 1980s showed common causes of death to be from substance use disorders and unintentional injuries.³⁻⁵ Studies from the 1990s revealed HIV/AIDS, when combined, to be a leading cause of death.^{6,7} More recently, unintentional overdose was shown to have replaced HIV/AIDS as a leading cause of death in the homeless population.¹⁰ Literature on the unsheltered population has shown that they have more risk factors for death, more behavioral health issues, more trauma, and poorer health than their sheltered counterparts.¹¹⁻¹³ However, these studies have not looked specifically at mortality outcomes for unsheltered individuals, whose unique blend of comorbidities and environmental exposures may place them at higher risk for death.

A better understanding of the demographics, mortality patterns, and causes of death among unsheltered individuals could inform social policy and clinical practice initiatives to improve outcomes in this vulnerable population. To address the current gap in the literature about this unique subpopulation, we conducted a 10-year, prospective cohort study using an unsheltered cohort from Boston, Massachusetts, that was established in 2000 and followed up through the end of 2009. We described the unsheltered cohort, examined causes of death, and calculated age-specific rate ratios and age-standardized all-cause and cause-specific mortality rates and compared this cohort with both the nonhomeless adult population living in Massachusetts and a cohort of homeless adults living in Boston who primarily slept in emergency shelters. We hypothesized that the unsheltered cohort would have higher all-cause and cause-specific mortality rates than the nonhomeless and sheltered homeless populations, and that those unsheltered homeless individuals would die prematurely from common but preventable and treatable causes, such as cancer, heart disease, and substance use disorders.

Methods

Study Population

The study population consisted of adults living outside who were primary care patients of the Boston Health Care for the Homeless Program’s (BHCHP’s) Street Team. Eligibility criteria for the study included the following: (1) sleeping outside

Key Points

Question What are the mortality patterns for unsheltered homeless adults who primarily sleep outdoors?

Findings In this 10-year cohort study of 445 unsheltered homeless adults, the age-standardized all-cause mortality rate was almost 3-fold larger than that for a cohort of homeless adults primarily sleeping in shelters and nearly 10-fold larger than that for the adult population of Massachusetts; both represented significant differences. Common causes of death were cancer and heart disease.

Meaning Interventions and models of care need to address the unique needs of the unsheltered homeless adult population to improve outcomes.

for 1 or more nights during 2000; (2) 18 years or older by January 1, 2000; (3) at least 1 face-to-face encounter with the BHCHP’s Street Team staff during 2000; and (4) a first and last name and either a date of birth or a Social Security number in the study database. Participants were excluded if there was a lack of identifying information in the study database. Of 568 records in the BHCHP’s Street Team database, 445 unsheltered adults (78.3%) met the eligibility criteria. The study was approved by the institutional review board of Boston University Medical Center, Boston, Massachusetts. Participant informed consent was waived by BHCHP. The study posed minimal risk to privacy.

Study Design and Data Collection

We conducted a 10-year prospective study from January 1, 2000, through December 31, 2009. Data analysis was performed from May 1, 2015, to September 6, 2016. Data from face-to-face encounters with the BHCHP’s Street Team were used for the study and stored prospectively. Face-to-face encounters for primary care consisted of a BHCHP’s Street Team clinician meeting an unsheltered individual on the street or at an outside location during a daytime or nighttime clinical session. The clinicians of the BHCHP’s Street Team documented these encounters on paper at the time of the visit and the notes were later transcribed by a research assistant into a database (Microsoft Office Access; Microsoft Corporation). Data collected at the initial and subsequent visits included the following information: first and last names, date and location of the encounter, date of birth, Social Security number, sex, race/ethnicity, medical and behavioral health diagnoses, and the name of the clinician performing the visit. Any new data, such as a date of death, was added to the database. The cohort had no known duplicates, and no individual was added to the cohort after December 31, 2000. Everyone in the cohort was alive at the time of enrollment.

After the study concluded, the database was matched to BHCHP’s electronic medical record to confirm data such as the correct spelling of the first and last name, sex, race/ethnicity, date of birth, and Social Security number. The records were then matched with the Massachusetts Department of Public Health death occurrence files from 2000 to 2009 (received on CD from Massachusetts Department of Public Health; November 3, 2014) in the manner described below to confirm deaths,

add the dates of deaths if they were previously unknown, and add the underlying and multiple causes of death. Over the course of the study, reports were requested from the National Death Index¹⁴ in 2006 and in 2011 to investigate the possibility of a death occurring outside the state for a proportion of the cohort whose whereabouts were unknown. Data extracted from the National Death Index¹⁴ reports included the date of death, the state in which death occurred, and the underlying and multiple causes of death.

All data describing the causes of death were in the format of the *International Statistical Classification of Diseases and Related Health Problems, Tenth Edition (ICD-10)* diagnosis codes. The data identifying the underlying and multiple causes of death taken from the Massachusetts Department of Public Health and the National Death Index¹⁴ were previously processed by the National Center for Health Statistics using well-established computer algorithms to select the underlying cause of death from conditions reported on death certificates. Underlying causes of death codes were used for this study and grouped based on previous literature.^{7,10,15,16} Definitions of codes from the Centers for Disease Control and Prevention (CDC) Wide-Ranging Online Data for Epidemiologic Research (WONDER) were also used for interpretation of the *ICD-10* codes.¹⁷ The *ICD-10* groupings, terminology, and definitions used to combine the *ICD-10* categories can be found in the eTable in the Supplement.

Race/ethnicity categories created by BHCHP were as follows: non-Hispanic white, non-Hispanic black, and persons of color/unknown identified as Asian, Hispanic, American Indian, or unknown race/ethnicity. Age categories included 18 to 44 years, 45 to 64 years, and 65 to 84 years. Sex was dichotomous without unknowns. There were 2 variables with missing data: Social Security number was missing in 15 of 445 records (3.4%) and race/ethnicity, 7 of 445 records (1.6%).

Comparison Groups

Two comparison groups (the Massachusetts population and a sheltered homeless cohort from Boston) were used to calculate the standardized mortality ratios (SMRs). Data for the Massachusetts population were taken from the CDC's WONDER for ages 18 to 84 years from 2000-2009. The Massachusetts population was chosen as a comparison group because our study methods were analogous to methods used in a 2013 study by Baggett et al,¹⁰ who also used the Massachusetts population as a comparison group.

Data for the adult homeless cohort were obtained from the 2013 study by Baggett et al.¹⁰ They retrospectively assembled a homeless cohort of 28 033 adults 18 years or older who had 1 or more encounters with a BHCHP clinician between January 1, 2003, and December 31, 2008.¹⁰ The comparison cohort included homeless adults who were seen by BHCHP from 2003 to 2008.¹⁰

Matching Data

Link Plus 2.0, a probabilistic record linkage program developed at the CDC Division of Cancer Prevention and Control in support of the CDC's National Program of Cancer Registries, was used to match BHCHP's data to the Massachusetts De-

partment of Public Health data. Each match was manually reviewed. A death record was accepted as a match if it had the same data on 1 or more of the following: Social Security number; first and last name and month and year of birth within a range of 1 year; or first and last name and month and day of birth.^{7,10,14} The algorithm was similar to that used by the National Death Index¹⁴ to match records and has been reliably used by previous researchers who studied mortality among homeless populations.^{7,10,14}

Statistical Analysis

We described the demographic characteristics of the unsheltered cohort overall and by subgroups, including sex and vital status (whether the cohort member was alive or dead and information about the decedent). Among those in the cohort who died, we noted the place of death and whether an autopsy was performed.

Crude mortality rates for all-cause and cause-specific mortality were calculated using the number of deaths in each category divided by person-years of observation for that category to create incident rates, expressed as events per 100 000 person-years. Strata-specific incident rate ratios were calculated by taking one crude mortality rate within a stratum and dividing it by another crude mortality rate within the same stratum. For rate ratios, women, non-Hispanic white, and the young age category (18-44 years) were used as reference groups.

Age-standardized all-cause and cause-specific mortality rates were calculated using indirect standardization, with the unsheltered cohort as the standard population. The SMRs were calculated as follows: by creating age-specific mortality rates per person-year for young (18-44 years), middle (45-64 years), and old age (65-84 years) categories for both the Massachusetts population and the adult homeless cohort; by multiplying the age-specific mortality rates by the age-specific person-years from the unsheltered cohort; by summing the 3 age-specific results to determine the expected number of deaths; and then by dividing the number of observed deaths by the number of expected deaths. The SMRs were calculated when the number of deaths in a category was 5 or more.¹⁵

Statistical analyses were performed using Stata, version 14 (StataCorp) and Microsoft Excel 2013 (Microsoft Corporation) and consisted of calculating incidence rates, rate ratios, and SMRs. Corresponding 95% CIs for rates and ratios were calculated using OpenEpi (Open Source Epidemiologic Statistics for Public Health), version 3.01.¹⁸ A 2-sided significance level of <.05 was used for testing.

Results

Cohort Characteristics

The study cohort comprised 445 unique unsheltered adults who were followed for a total of 3608.7 person-years (mean, 8.2 years; range 0.1-9.9 years). The mean (SD) age at enrollment was 44 (11.4) years with a range of 18 to 81 years. Of 445 participants in the cohort, 299 (67.2%) were non-Hispanic white and 322 (72.4%) were men (Table 1).

Table 1. Characteristics of the Unsheltered Cohort, 2000-2009

Characteristic	No. (%)				Sheltered Adult Homeless Cohort ≥ 18 y (n = 28 033) ^a	MA 2000 Census Population ≥ 18 y (n = 4 849 033) ^b
	Unsheltered Adult Homeless Cohort Full Cohort (N = 445)	Men (n = 322)	Women (n = 123)	Decedents (n = 134)		
Age, y						
18-44	248 (55.7)	165 (51.2)	83 (67.5)	56 (41.8)	17 298 (61.8)	2 569 111 (53.0)
45-64	176 (39.6)	140 (43.5)	36 (29.3)	65 (48.5)	9924 (35.4)	1 419 760 (29.3)
≥65	21 (4.7)	17 (5.3)	4 (3.3)	13 (9.7)	811 (2.8)	860 162 (17.7)
Race/ethnicity						
Non-Hispanic white	299 (67.2)	223 (69.3)	76 (61.8)	108 (80.6)	11 912 (42.5)	4 180 644 (86.1)
Non-Hispanic black	94 (21.1)	62 (19.3)	32 (26.0)	15 (11.2)	8066 (28.8)	236 027 (4.9)
Persons of color or unknown ^c	52 (11.7)	37 (11.5)	15 (12.2)	11 (8.2)	8055 (28.7)	432 362 (8.9)
Sex						
Men	322 (72.4)	NA	NA	116 (86.6)	18 612 (66.4)	2 289 671 (47.2)
Women	123 (27.6)	NA	NA	18 (13.4)	9421 (33.6)	2 559 362 (52.8)

Abbreviations: MA, Massachusetts; NA, not applicable.

^a Adult homeless cohort from the study by Baggett et al.¹⁰

^b Based on US Census Bureau data.¹⁹

^c Individuals who identified as Asian, Hispanic, American Indian, or whose race/ethnicity was unknown.

Table 2. Stratum-Specific Mortality Rates and Rate Ratios of Unsheltered Cohort, 2000-2009

Characteristic	Deaths, No. (%)	Person-Years, No.	Mortality Rate, Deaths per 100 000 Person-Years (95% CI)	Rate Ratio (95% CI)	P Value
Overall	134 (100)	3608.7	3713.2 (3110.9-4397.5)	NA	NA
Age, y					
18-44	56 (41.8)	2124.6	2635.8 (1990.7-3422.2)	1 [Reference]	NA
45-64	65 (48.5)	1350.3	4813.8 (3716.0-6136.9)	1.8 (1.3-2.7)	<.001
65-84	13 (9.7)	133.8	9715.9 (5165.6-16589.9)	3.7 (1.8-6.8)	<.001
Race/ethnicity					
Non-Hispanic white	108 (80.6)	2325.2	4644.7 (3810.5-5608.3)	1 [Reference]	NA
Non-Hispanic black	15 (11.2)	835.4	1795.5 (1005.4-2962.9)	0.4 (0.2-0.7)	<.001
Persons of color or unknown ^a	11 (8.2)	448.1	2455.1 (1225.7-4393.3)	0.5 (0.3-1.0)	.03
Sex					
Women	18 (13.4)	1130.6	1592.1 (943.2-2515.3)	1 [Reference]	NA
Men	116 (86.6)	2478.1	4681.0 (3868.2-5614.7)	2.9 (1.8-5.1)	<.001

Abbreviation: NA, not applicable.

^a Individuals who identified as Asian, Hispanic, American Indian, or whose race/ethnicity was unknown.

Decedent Characteristics

Of the 445 unsheltered adults, 134 died during the study period. A total of 122 deaths were confirmed through linkage with the Massachusetts Department of Public Health data, and an additional 12 records were manually matched to the National Death Index¹⁴ reports. The mean (SD) age at death was 53 (11.4) years. Of the 134 decedents, 116 (86.6%) were men and 108 (80.6%) were non-Hispanic white. A mean (SD) of 13 (3.4) deaths per year occurred throughout the study. Most deaths (87 of 134 [64.9%]) occurred inside a health care facility (ie, inpatient wards, outpatient clinics, emergency departments, and nursing homes), and 48 (35.8%) resulted in an autopsy.

Mortality Rates

The crude mortality rate overall was 3713.2 (95% CI, 3110.9-4397.5) deaths per 100 000 person-years (Table 2). The race/ethnicity specific mortality rate ratio for non-Hispanic blacks was 0.4 times the rate ratio of death for non-Hispanic whites

(95% CI, 0.2-0.7; $P < .001$) (Table 2). The SMR for the unsheltered cohort was 9.8 (95% CI, 8.2-11.5) relative to the Massachusetts population and 2.7 (95% CI, 2.3-3.2) relative to the sheltered adult homeless cohort (Table 3).

Causes of Death

Thirty-nine deaths (29.1%) were directly attributable to substance use disorders and unintentional overdose (Table 3). Non-poisoning injuries represented 19 of the 134 deaths (14.2%). Mortality rates in the unsheltered cohort for HIV/AIDS (10 of 134 deaths [7.5%]) were considerably higher than rates in the Massachusetts population and in the sheltered adult homeless cohort, and SMRs were significantly elevated among the unsheltered cohort when compared with both the Massachusetts population (SMR, 63.8; 95% CI, 32.4-113.8) and the sheltered adult homeless cohort (SMR, 3.4; 95% CI, 1.7-6.0). The one exception was drug overdose, which did not differ between the unsheltered cohort and adult homeless cohort (SMR,

Table 3. Age-Standardized All-Cause and Cause-Specific Mortality Ratios for the Unsheltered Cohort (2000-2009) Compared With the Massachusetts Population (2000-2009) and With a Sheltered Adult Homeless Cohort (2003-2008)^a

Underlying Cause of Death ^b	Overall Deaths, No. (%) (n = 134)	SMR (95% CI) ^c	
		Unsheltered Homeless Adults vs MA Population	Unsheltered vs Sheltered Homeless Adults
All causes for entire cohort	134 (100)	9.8 (8.2-11.5)	2.7 (2.3-3.2)
Natural causes			
Cancer	21 (15.7)	4.8 (3.1-7.3)	2.8 (1.8-4.2)
Heart diseases	18 (13.4)	6.4 (3.9-9.9)	2.4 (1.4-3.7)
Chronic substance use	16 (11.9)	88.9 (52.7-141.5)	4.2 (2.5-6.7)
Chronic liver disease	15 (11.2)	32.2 (18.7-51.9)	4.5 (2.6-7.3)
HIV/AIDS	10 (7.5)	63.8 (32.4-113.8)	3.4 (1.7-6.0)
Ill-defined conditions	5 (3.7)	26.8 (9.8-59.3)	NC
External causes			
Nonpoisoning injuries ^d	19 (14.2)	33.3 (20.7-51.1)	7.1 (4.4-11.0)
Drug overdose	8 (6.0)	14.1 (6.5-26.7)	0.9 (0.4-1.7) ^e
Substance use disorder causes			
Alcohol use disorder	30 (22.4)	110.2 (75.7-155.3)	NC
Opioid use disorder	9 (6.7)	15.7 (7.6-28.8)	NC

Abbreviations: ICD-10, *International Statistical Classification of Diseases and Related Health Problems, Tenth Revision*; MA, Massachusetts; NC, not calculated; SMR, standardized mortality ratio.

^a Adult sheltered homeless cohort from the study by Baggett et al.¹⁰

^b There were no unknown causes of death, and fewer than 5 deaths in each category were suppressed.

^c The SMR was calculated when there were 5 or more deaths in each category.

^d Nonpoisoning injuries (ICD-10 diagnosis codes): transportation accidents (codes V01-V99), other external causes of accidental injuries (codes W00-X59, except X40-X49), and events of undetermined intent (codes Y20-Y34, except Y10-Y19). Methodology in combining the ICD-10 categories were based on the Health of Boston 2014-2015 report.¹⁵

^e The SMR was not significant.

0.9; 95% CI, 0.4-1.7). No deaths occurred from diabetes or tuberculosis. External causes, such as suicide, homicide, and hypothermia, which were included in the nonpoisoning injury category, accounted for fewer than 5 deaths each.

Discussion

All-cause mortality rates in the unsheltered cohort were nearly 3 times greater than those in an adult homeless cohort and almost 10 times greater than in the Massachusetts population. Our cause-specific mortality findings underscore a high burden of substance use in this population. In addition to the deaths directly attributable to substance use, many of the deaths due to nonpoisoning injuries, which primarily included motor vehicle crashes, falls, and drownings, have been shown by previous researchers to be related to alcohol or other drug use.²⁰⁻²² The SMR for nonpoisoning injuries was high for the unsheltered cohort compared with the adult homeless cohort; these results may indicate a possibly greater risk of death for rough sleepers, but more research is warranted. Other common causes of death, such as cancer and heart disease, have a strong link to cigarette smoking, which is highly prevalent among homeless people.²⁰ To effectively decrease morbidity and mortality in the unsheltered population, it is necessary to have fully integrated clinical outreach teams to meet rough sleepers where they live on the streets in order to establish and maintain continuity of care.^{13,23,24} Addiction treatment and recovery programs should be readily available, with treatment on demand to support motivation for action and prevent fur-

ther morbidity and mortality. Future research should include harm reduction policies, such as managed alcohol programs or supervised injection sites within shelters and homeless programs, which might make shelters more tolerable for those who currently fear substance abuse withdrawal.^{25,26}

Higher rates of death among non-Hispanic white individuals compared with non-Hispanic black individuals and persons of color have been consistently observed in previous studies of homeless persons, and the causes for this phenomenon are likely multifactorial.^{2,4,5,7,8,10} Similarly, studies have shown that homeless men have higher rates of death than homeless women. Non-Hispanic white individuals and men, on average, have more economic resources than non-Hispanic black individuals and women and are less likely to have experienced adverse social and economic effects due to bias or discrimination.²⁷ Thus, non-Hispanic white individuals and men may, on average, have reached a higher threshold of comorbidities at the time that they become homeless compared with non-Hispanic black individuals and persons of color. Men, whether or not they are homeless, are at a higher risk of death at an earlier age than women because of risk-taking behaviors related to the male sex. However, more research with empirical data needs to be conducted to fully understand these disparities among the unsheltered homeless.

Limitations

Although the study was subject to some biases that we could not control, we believe the influences were minor. Some unsheltered adults living on the streets of Boston may not have been seen by BHCHP's Street Team during enrollment and were

not included in the cohort, which created a potential selection bias toward those homeless adults who sought health services. Since Boston is a moderately sized city with an extensive network of outreach services provided by the BHCHP's Street Team and their community partners, the number of individuals not served by BHCHP during enrollment was likely to have been small. Additional bias could have occurred if someone entered the cohort and then traveled to another state and died while living in another state. Obtaining National Death Index¹⁴ records improved our ability to detect deaths that occurred outside the state. The BHCHP's Street Team database contained 123 records with insufficient identifying information to be included in the study. These excluded individuals could be systematically different from individuals included in the study in important ways, such as their level of illness or the length of time that they were homeless. Based on our clinical experience, an alternative explanation was that most of these records with insufficient identifying information were duplicate records of identified cohort members because a new record was opened, rather than an existing one updated, when identifiers were learned.

Additional limitations included a lack of information about individual comorbidities or the chronicity of being homeless before or during the observation period; both could have contributed to a more nuanced understanding of mortality risk in this population. Some causes of death were too rare to ascertain mortality rates. A larger cohort would be required to address this limitation in future studies. Some overlap of the 2 homeless cohorts may have occurred, but the overlap was believed to have been small because BHCHP's data on sleeping location from 2008 showed that the proportion of patients sleeping outside was small (1%-3%) and the time frames of the 2 cohorts were not exact. If there was overlap, estimates of mortality using the sheltered adult homeless cohort as a comparison would be conservative.

Choosing Massachusetts as a comparison population instead of Boston could be considered a limitation of the study; however, some of our methods were based on those used by Baggett et al¹⁰ in their 2013 study, in which the Massachusetts population was the comparison group. In addition, during the time frame of the study, the age-adjusted, all-cause mortality rate in Boston (687 per 100 000 population) was only slightly higher than the age-adjusted, all-cause mortality rate for Massachusetts (669 per 100 000 population).^{15,28} We anticipated that confounding by race/ethnicity would be minimal given that the study cohort was disproportionately

of non-Hispanic white race/ethnicity as was the Massachusetts population.

Generalizability to cities outside Boston could be affected by difference in access to homeless shelters, health insurance, and health care. Boston guarantees each homeless person access to emergency homeless shelters each night.²⁹ Not every city across the United States makes this guarantee, and the homeless people accessing shelters in Boston may differ from the homeless accessing, or not accessing, shelters in another city. Most of Boston's shelters have few limits on the length of stay and have little to no requirements regarding sobriety. These shelters accept individuals struggling with alcohol and other drugs, an important factor in minimizing the number of unsheltered individuals in Boston. Shelters in many cities have limits on the length of stay or requirements for sobriety and do not allow individuals with active substance use disorders, which increases the number of homeless people living outside. Access to health care and health insurance were available to our cohort, but it was not uniform across the United States, particularly during the time of the study. These factors could influence mortality for those individuals sleeping outside in different locations and thereby influence the generalizability of our results. Our study provides important insights about mortality patterns in this previously overlooked group of highly vulnerable individuals.

Conclusions

Our study results showed that unsheltered adults had a higher all-cause mortality rate than a mostly sheltered homeless adult population in Boston, a finding that to our knowledge is not previously reported in the literature. The unsheltered cohort died at a relatively young age of both noncommunicable and substance-attributable causes of death. Access to a patient-centered, outreach service model with integrated medical and behavioral health care delivered directly to the unsheltered population is necessary to begin to address these disparities. A better understanding of the social and supportive services is necessary to augment an integrated outreach team. Services such as harm-reduction models; greater availability and access to substance use disorder treatment, including smoking cessation; and a continuum of housing models with flexible social services to meet individual needs for successful tenancies and improved health are also needed to ultimately improve health disparities borne by those sleeping outside.³⁰

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REFERENCES

- US Department of Housing and Urban Development. The 2017 Annual Homeless Assessment Report (AHAR) to Congress, part 1: point-in-time estimates of homelessness. Published 2017. <https://www.hudexchange.info/resources/documents/2017-ahar-part-1.pdf>. Accessed January 11, 2018.
- Barrow SM, Herman DB, Córdova P, Struening EL. Mortality among homeless shelter residents in New York City. *Am J Public Health*. 1999;89(4):529-534. doi:10.2105/AJPH.89.4.529
- Centers for Disease Control (CDC). Deaths among the homeless—Atlanta, Georgia. *MMWR Morb Mortal Wkly Rep*. 1987;36(19):297-299.
- Centers for Disease Control (CDC). Deaths among homeless persons—San Francisco, 1985-1990. *MMWR Morb Mortal Wkly Rep*. 1991;40(50):877-880.
- Hibbs JR, Benner L, Klugman L, et al. Mortality in a cohort of homeless adults in Philadelphia. *N Engl J Med*. 1994;331(5):304-309. doi:10.1056/NEJM199408043310506
- Hwang SW, Lebow JM, Bierer MF, O'Connell JJ, Orav EJ, Brennan TA. Risk factors for death in homeless adults in Boston. *Arch Intern Med*. 1998;158(13):1454-1460. doi:10.1001/archinte.158.13.1454
- Hwang SW, Orav EJ, O'Connell JJ, Lebow JM, Brennan TA. Causes of death in homeless adults in Boston. *Ann Intern Med*. 1997;126(8):625-628. doi:10.7326/0003-4819-126-8-199704150-00007
- KasproW WJ, Rosenheck R. Mortality among homeless and nonhomeless mentally ill veterans. *J Nerv Ment Dis*. 2000;188(3):141-147. doi:10.1097/00005053-200003000-00003
- Hwang SW, Wilkins R, Tjepkema M, O'Campo PJ, Dunn JR. Mortality among residents of shelters, rooming houses, and hotels in Canada: 11 year follow-up study. *BMJ*. 2009;339:b4036. doi:10.1136/bmj.b4036
- Baggett TP, Hwang SW, O'Connell JJ, et al. Mortality among homeless adults in Boston: shifts in causes of death over a 15-year period. *JAMA Intern Med*. 2013;173(3):189-195. doi:10.1001/jamainternmed.2013.1604
- Levitt AJ, Culhane DP, DeGenova J, O'Quinn P, Bainbridge J. Health and social characteristics of homeless adults in Manhattan who were chronically or not chronically unsheltered. *Psychiatr Serv*. 2009;60(7):978-981. doi:10.1176/ps.2009.60.7.978
- Montgomery AE, Szymkowiak D, Marcus J, Howard P, Culhane DP. Homelessness, unsheltered status, and risk factors for mortality: findings from the 100 000 homes campaign. *Public Health Rep*. 2016;131(6):765-772. doi:10.1177/0033354916667501
- Nyamathi AM, Leake B, Gelberg L. Sheltered versus nonsheltered homeless women: differences in health, behavior, victimization, and utilization of care. *J Gen Intern Med*. 2000;15(8):565-572. doi:10.1046/j.1525-1497.2000.07007.x
- National Center for Health Statistics. National Death Index. <https://www.cdc.gov/nchs/ndi/index.htm>. Accessed June 18, 2018.
- Health of Boston 2014-2015. Boston, MA: Research & Evaluation Office, Boston Public Health Commission; 2015. http://www.bphc.org/healthdata/health-of-boston-report/documents/hob-2014-2015/fullreport_hob_2014-2015.pdf. Accessed September 19, 2016.
- Instruction Manual, Part 9: ICD-10 Cause-of-Death Lists for Tabulating Mortality Statistics (Updated March 2011 to Include WHO Updates to ICD-10 for Data Year 2011). Hyattsville, MD: National Center for Health Statistics, Centers for Disease Control & Prevention, US Dept of Health & Human Services; March 2011. <https://www.cdc.gov/nchs/data/dvs/part9instructionmanual2011.pdf>. Accessed September 19, 2016.
- Centers for Disease Control and Prevention Wide-Ranging Online Data for Epidemiologic Research (WONDER): about underlying cause of death, 1999-2016. <https://wonder.cdc.gov/icd10.html>. Accessed June 18, 2018.
- Dean AG, Sullivan KM, Soe MM. OpenEpi: open source epidemiologic statistics for public health, version 3.01. Updated April 6, 2013. <http://www.OpenEpi.com>. Accessed September 19, 2016.
- US Census Bureau. Census 2000 summary file 1 (SF 1) 100-percent data: sex by age. American FactFinder. https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=DEC_00_SF1_P012&prodType=table. Accessed March 18, 2016.
- Baggett TP, Chang Y, Singer DE, et al. Tobacco-, alcohol-, and drug-attributable deaths and their contribution to mortality disparities in a cohort of homeless adults in Boston. *Am J Public Health*. 2015;105(6):1189-1197. doi:10.2105/AJPH.2014.302248
- Single E, Rehm J, Robson L, Truong MV. The relative risks and etiologic fractions of different causes of death and disease attributable to alcohol, tobacco and illicit drug use in Canada. *CMAJ*. 2000;162(12):1669-1675.
- Single E, Robson L, Rehm J, Xie X. Morbidity and mortality attributable to alcohol, tobacco, and illicit drug use in Canada [published correction appears in *Am J Public Health*. 1999;89(5):785]. *Am J Public Health*. 1999;89(3):385-390. doi:10.2105/AJPH.89.3.385
- Brickner PW, Scanlan BC, Conanan B, et al. Homeless persons and health care. *Ann Intern Med*. 1986;104(3):405-409. doi:10.7326/0003-4819-104-3-405
- Petrovich JC, Cronley CC. Deep in the heart of Texas: a phenomenological exploration of unsheltered homelessness. *Am J Orthopsychiatry*. 2015;85(4):315-323. doi:10.1037/ort0000043
- Potier C, Lapr vete V, Dubois-Arber F, Cottencin O, Rolland B. Supervised injection services: what has been demonstrated? a systematic literature review. *Drug Alcohol Depend*. 2014;145:48-68. doi:10.1016/j.drugalcdep.2014.10.012
- Podymow T, Turnbull J, Coyle D, Yetsiris E, Wells G. Shelter-based managed alcohol administration to chronically homeless people addicted to alcohol. *CMAJ*. 2006;174(1):45-49. doi:10.1503/cmaj.1041350
- Pruitt L. Welfare queens and white trash. *Southern California Interdisciplinary Law Journal*. 2016;25:289-312. UC Davis Legal Studies Research Paper No. 486. Updated April 26, 2016. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2740095. Accessed September 19, 2016.
- Office of Data Management and Outcomes Assessment, Massachusetts Department of Public Health. *Massachusetts Deaths 2012: Data Brief*. Boston: Massachusetts Dept of Public Health; 2015. <https://www.mass.gov/files/documents/2016/07/mx/death-databrief-2012.pdf>. Accessed January 12, 2018.
- Emergency Health Commission. *Dignity and Respect: Making Room for Boston's Homeless: A Report on the City of Boston's Comprehensive Policy for Boston's Homeless*. Boston, MA: Emergency Shelter Commission; 1987. <https://archive.org/details/dignityrespectma00bost>. Accessed September 19, 2016.
- Aubry T, Tsemberis S, Adair CE, et al. One-year outcomes of a randomized controlled trial of housing first with ACT in five Canadian cities. *Psychiatr Serv*. 2015;66(5):463-469. doi:10.1176/appi.ps.201400167