Mortality Among Homeless Adults in Boston

Shifts in Causes of Death Over a 15-Year Period

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Background: Homeless persons experience excess mortality, but US-based studies on this topic are outdated or lack information about causes of death. To our knowledge, no studies have examined shifts in causes of death for this population over time.

Methods: We assessed all-cause and cause-specific mortality rates in a cohort of 28 033 adults 18 years or older who were seen at Boston Health Care for the Homeless Program from January 1, 2003, through December 31, 2008. Deaths were identified through probabilistic linkage to the Massachusetts death occurrence files. We compared mortality rates in this cohort with rates in the 2003-2008 Massachusetts population and a 1988-1993 cohort of homeless adults in Boston using standardized rate ratios with 95% confidence intervals.

Results: A total of 1302 deaths occurred during 90 450 person-years of observation. Drug overdose (n=219), cancer (n=206), and heart disease (n=203) were the major causes of death. Drug overdose accounted for one-third of deaths among adults younger than 45 years. Opioids were implicated in 81% of overdose deaths. Mortality rates were higher among whites than nonwhites. Compared with Massachusetts adults, mortality disparities were most pronounced among younger individuals, with rates about 9-fold higher in 25- to 44-year-olds and 4.5-fold higher in 45- to 64-year-olds. In comparison with 1988-1993 rates, reductions in deaths from human immunodeficiency virus (HIV) were offset by 3- and 2-fold increases in deaths owing to drug overdose and psychoactive substance use disorders, resulting in no significant difference in overall mortality.

Conclusions: The all-cause mortality rate among homeless adults in Boston remains high and unchanged since 1988 to 1993 despite a major interim expansion in clinical services. Drug overdose has replaced HIV as the emerging epidemic. Interventions to reduce mortality in this population should include behavioral health integration into primary medical care, public health initiatives to prevent and reverse drug overdose, and social policy measures to end homelessness.

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AN ESTIMATED 2.3 TO 3.5 million Americans experience homelessness annually,[1] and over 649 000 are homeless on a single night.[2] Homeless individuals have a high prevalence of physical illness, psychiatric disease, and substance abuse,[3-5] contributing to very high mortality rates in comparison with nonhomeless people.[6-17]

Despite the persistence of homelessness in the United States, the past decade has yielded few studies on mortality among homeless Americans, and information on causes of death in this population is sparse. In the most recent study that examined causes of death in a US-based homeless population, Hwang et al[7] analyzed data on 17 292 adults seen at Boston Health Care for the Homeless Program (BHCHP) in 1988 to 1993. This study documented the substantial toll of human immunodeficiency

(HIV) infection, which was the leading cause of death among 25- to 44-year-olds and accounted for 18% of all deaths in the study cohort. Homicide was the principal cause of death for 18- to 24-year-olds, while heart disease and cancer were the leading causes among 45- to 64-year-olds.

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In view of interim advances in HIV treatment and expansion of federally funded Health Care for the Homeless clinical services, the mortality profile of homeless adults in the United States may have changed since 1988 to 1993; however, data to confirm this are lacking. A comprehen-

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sive reassessment of mortality and causes of death among homeless adults would provide a needed update on the health status of this vulnerable population and inform policy decisions and clinical practice priorities regarding the provision of health care and other services for this group of people.

Using methods similar to the 1988-1993 Boston mortality study,[7] we assessed overall and cause-specific mortality rates in a large cohort of adults who used services provided by BHCHP from 2003 to 2008. We compared these mortality rates with those of the general population of Massachusetts residents from 2003 to 2008 and to the cohort of homeless adults seen by BHCHP in 1988 to 1993. We also examined racial variations in mortality since prior studies of homeless individuals have found paradoxically higher death rates among whites than nonwhites.[6,12,18]

METHODS

PARTICIPANTS AND SETTING

We retrospectively assembled a cohort of all adults at least 18 years old who had an in-person encounter at BHCHP between January 1, 2003, and December 31, 2008. BHCHP serves more than 11 000 individuals annually in over 90 000 outpatient medical, oral health, and behavioral health encounters through a network of over 80 service sites based in emergency shelters, transitional housing facilities, hospitals, and other social service settings in greater Boston.[19,20] Patients must be homeless to enroll in services at BHCHP; no other eligibility requirements are imposed. Some patients elect to continue receiving care at BHCHP after they are no longer homeless. Owing to limitations in the data, we were unable to distinguish currently vs formerly homeless participants, so this study represents an analysis of adults who have ever experienced homelessness. We refer to this group as "homeless" for simplicity. Individuals were observed from the date of first contact within the study period until the date of death or December 31, 2008. We measured observation time in person-years. The Partners Human Research Committee approved this study.

ASCERTAINMENT OF VITAL STATUS

We used LinkPlus software (version 2.0; Centers for Disease Control and Prevention [CDC]) to cross-link the BHCHP cohort with the Massachusetts Department of Public Health (MDPH) death occurrence files for 2003 to 2008. LinkPlus is a probabilistic record linkage software program that uses expectation maximization algorithms and an array of linkage tools to compute linkage probability scores for possible record pairs based on the level of agreement and relative importance of various personal identifiers.[21] Our primary linkage procedure used first and last name, date of birth, and social security number (SSN); sensitivity analyses used sex and race with no additional linkages identified. There were minimal missing data for the core identifiers in the BHCHP cohort (0% for name and birth date, 9% for SSN). We manually reviewed record pairs achieving a probability score of 7 or higher[21] and generally accepted a record pair as a true linkage if it matched on one of the following National Death Index criteria[22] that were also used in the 1988-1993 BHCHP mortality study[7]: (1) SSN, (2) first and last name, month and year of birth (±1 year), or (3) first and last name, month, and day of birth. Two investigators (T.P.B. and B.C.P.) independently conducted the manual review with very high concordance and interrater reliability ($\kappa = 0.99$). A third investigator (J.J.O.) adjudicated discrepancies.

CAUSES OF DEATH

We based causes of death on the *International Statistical Classification of Diseases, 10th Revision (ICD-10)* underlying cause of death codes in the MDPH mortality file (eTable; http://www.jamainternalmed.com). The MDPH translates death certificate entries into *ICD-10* cause of death codes using software developed by the National Center for Health Statistics (NCHS).[23] We defined "drug overdose" as drug poisoning deaths that were unintentional (codes X40-X44) or of undetermined intent (codes Y10-Y14).[24] We included undetermined intent drug poisonings in this definition because Massachusetts medical examiners made relatively frequent use of this category prior to a 2005 policy change at the Office of the Chief Medical Examiner requiring that most of these deaths be categorized as unintentional.[23,25] In addition, evidence suggests that poisonings of undetermined intent more closely resemble unintentional poisonings than suicidal poisonings.[26] For drug overdose deaths, we examined the multiple cause of death fields to ascertain which substances were implicated in each overdose. We classified deaths due to alcohol poisoning (codes X45, Y15) separately from drug overdose. Drug- and alcohol-related deaths could also be captured under the *ICD-10* underlying cause of death codes for mental and behavioral disorders due to psychoactive substance use (codes F10-F19), which we analyzed collectively as "psychoactive substance use disorders." These codes are generally intended for deaths related to a chronic pattern or sequel of substance abuse rather than acute poisoning.[27] Such deaths include those attributed to substance dependence (eg, chronic alcoholism), harmful substance use resulting in medical complications (eg, dilated cardiomyopathy, gastrointestinal hemorrhage, aspiration pneumonia), and substance withdrawal syndromes (eg, delirium tremens) (Robert N. Anderson, PhD, Chief, Mortality Statistics Branch, NCHS, written communication, June 22, 2012).

STATISTICAL ANALYSIS

We tabulated the leading causes of death overall and stratified by age and sex. We calculated mortality rates by dividing the number of deaths by the person-years of observation and expressed these rates as deaths per 100 000 person-years. Since the accuracy of the underlying cause of death may depend on whether a decedent underwent autopsy, we assessed the percentage of homeless decedents who underwent autopsy and used the χ^2 test to compare this with the percentage who underwent autopsy in the Massachusetts general population.

To compare our age- and sex-stratified findings with the 2003-2008 Massachusetts general population, we adjusted for race using direct standardization with weights chosen according to the racial breakdown in the general population. We then calculated overall and cause-specific mortality rate ratios by dividing the race-standardized mortality rates in the homeless cohort by the rates in the general population. We fitted 95% confidence intervals using conventional methods for standardized rate ratios.[28,29] We obtained mortality data for the 2003-2008 Massachusetts general population from the CDC Wide-ranging Online Data for Epidemiologic Research (WONDER) underlying cause of death compressed mortality files.[30]

To compare our findings with the 1988-1993 BHCHP cohort, we directly standardized the overall and cause-specific mortality rates in the 2003-2008 cohort to match the age, sex, and race distribution of the 1988-1993 cohort. We limited this portion of the analysis to 18- to 64-year-olds to correspond to the age range analyzed in 1988 to 1993. From 1988 to 2008, BHCHP experienced substantial growth in the density and intensity of its clinical operations but did not change its core mission, geographical service area, target population, or eligibility requirements for pa-

Table 1. Characteristics of the Entire Study Cohort and the Decedents

Characteristic	No. (%)
Entire Cohort (n = 28 033)	
Age at index observation, mean (SD), y	41.0 (12.4)
18-24	3493 (12.5)
25-44	13 805 (49.3)
45-64	9924 (35.4)
65-84	793 (2.8)
≥85	18 (0.1)
Sex	
Male	18 612 (66.4)
Female	9421 (33.6)
Race/ethnicity	
White, non-Hispanic	11 912 (42.5)
Black, non-Hispanic	8066 (28.8)
Hispanic	5301 (18.9)
Other/unknown	2754 (9.8)
Decedents (n = 1302)	
Age at death, mean (range), y	51.2 (19.3-93.5)
Sex	
Male	1055 (81.0)
Female	247 (19.0)
Race	
White, non-Hispanic	784 (60.2)
Black, non-Hispanic	301 (23.1)
Hispanic	131 (10.1)
Other/unknown	86 (6.6)
Veteran	164 (12.6)
Place of death	
Hospital	683 (52.5)
Residence	352 (27.0)
Nursing home	129 (9.9)
Other	138 (10.6)
Autopsy performed	
Yes	495 (38.0)
No	807 (62.0)

Table 2. Causes of Death and Crude Mortality Rates

Underlying Cause of Death[a]	Deaths, No. (% of Total)	Crude Rate per 100 000 Person-years (95% CI)
All causes	1302 (100)	1439.5 (1361.3-1517.7)
Drug overdose	219 (16.8)	242.1 (210.1-274.2)
Cancer	206 (15.8)	227.8 (196.6-258.9)
Trachea, bronchus, and lung	74 (5.7)	81.8 (63.2-100.5)
Liver and intrahepatic bile ducts	24 (1.8)	26.5 (15.9-37.1)
Colon, rectum, and anus	18 (1.4)	19.9 (10.7-29.1)
Esophagus	11 (0.8)	12.2 (5.0-19.3)
Pancreas	8 (0.6)	8.8 (2.7-15.0)
Heart disease	203 (15.6)	224.4 (193.6-255.3)
Psychoactive substance use disorder	99 (7.6)	109.5 (87.9-131.0)
Alcohol use disorder	71 (5.5)	78.5 (60.2-96.8)
Other substance use disorders	28 (2.2)	31.0 (19.5-42.4)
Liver disease	89 (6.8)	98.4 (78.0-118.8)
Chronic liver disease and cirrhosis	58 (4.5)	64.1 (47.6-80.6)
Other liver diseases	31 (2.4)	34.3 (22.2-46.3)
HIV	76 (5.8)	84.0 (65.1-102.9)
Ill-defined conditions	41 (3.1)	45.3 (31.5-59.2)
Suicide	36 (2.8)	39.8 (26.8-52.8)
Transport accident	26 (2.0)	28.7 (17.7-39.8)
Pedestrian injured in transport accident	15 (1.2)	16.6 (8.2-25.0)
Cerebrovascular disease	25 (1.9)	27.6 (16.8-38.5)
Diabetes mellitus	24 (1.8)	26.5 (15.9-37.1)
Other accidents	23 (1.8)	25.4 (15.0-35.8)
Sepsis	22 (1.7)	24.3 (14.2-34.5)
Homicide	21 (1.6)	23.2 (13.3-33.1)
Nephritis, nephrotic syndrome, and nephrosis	21 (1.6)	23.2 (13.3-33.1)
Events of undetermined intent	21 (1.6)	23.2 (13.3-33.1)
Chronic lower respiratory diseases	20 (1.5)	22.1 (12.4-31.8)
Viral hepatitis	18 (1.4)	19.9 (10.7-29.1)
Anoxic brain injury	12 (0.9)	13.3 (5.8-20.8)
Influenza and pneumonia	11 (0.8)	12.2 (5.0-19.3)
Metabolic disorders	8 (0.6)	8.8 (3.8-17.4)
Alcohol poisoning	6 (0.5)	6.6 (2.4-14.4)
All other causes	75 (5.8)	82.9 (64.2-101.7)

Abbreviation: HIV, human immunodeficiency virus.

[a] Causes of death are based on the *International Statistical Classification of Diseases, 10th Revision (ICD-10)*. See the eTable (http://www.jamainternalmed.com) for the *ICD-10* codes used to define each cause of death.

tient enrollment.[20] To gauge the potential impact of this clinical expansion, we distinguished between natural and external causes of death (eTable)[27] because the former may be more responsive to traditional medical interventions. Since causes of death were classified according to *ICD-9* codes in the 1988-1993 cohort and *ICD-10* codes in the 2003-2008 cohort, we applied comparability ratios (CRs) (eTable) using methods outlined by the NCHS.[31-33] We used the CR for drug-induced deaths to analyze drug overdose mortality. We used the CR for alcohol-induced deaths to analyze mortality due to psychoactive substance use disorders since most of these deaths were alcohol-related.

To assess for racial differences in mortality, we compared the age-standardized all-cause mortality rates for white, black, and Hispanic adults, stratified by sex. We used SAS statistical software (version 9.3; SAS Institute Inc) and Microsoft Excel 2003 (Microsoft Corp) to conduct our analyses.

RESULTS

A total of 28 033 adults were followed for a median of 3.3 years, yielding 90 450 person-years of observation. The mean age at cohort entry was 41 years (**Table 1**). In comparison with the 1988-1993 cohort, individuals 45 years or older comprised a greater proportion of observation time (45% vs 29%). Two-thirds of participants were male, and 42.5% were white.

There were 1302 deaths during the study period, generating a crude mortality rate of 1439.5 deaths per 100 000 person-years. The mean age at death was 51 years (range, 19-93 years) (Table 1). Over 80% of decedents were male, and 60.2% were white. Most deaths occurred in a hospital. Overall, 38.0% of decedents in the study cohort underwent autopsy compared with 6.7% of decedents in the Massachusetts general population (*P* < .001).

MAJOR CAUSES OF DEATH

Drug overdose was the leading cause of death, accounting for 16.8% of all deaths in the cohort (**Table 2**). Opioids were implicated in 81% of overdose deaths; of these, heroin was identified in 13%, opioid analgesics in 31%, and other and unspecified narcotics in 60%. Cocaine contributed to 37% of overdose deaths, and 43% involved multiple substances. Alcohol was mentioned as a co-occurring substance in 32% of drug overdose deaths.

Table 3. Leading Causes of Death and Race-Adjusted Mortality Rate Ratios (RRs) by Age Group and Sex

25-44 Years			45-64 Years			65-84 Years		
Cause	No.	CR[a]	Race-Adjusted RR[b] (95% CI)	Cause	No.	CR[a]	Race-Adjusted RR[b] (95% CI)	Cause	No.	CR[a]	Race-Adjusted RR[b] (95% CI)

Cause	No.	CR[a]	Race-Adjusted RR[b] (95% CI)	Cause	No.	CR[a]	Race-Adjusted RR[b] (95% CI)	Cause	No.	CR[a]	Race-Adjusted RR[b] (95% CI)
Men											
Drug overdose	92	346.9	16.0 (12.6-20.3)	Cancer	120	418.7	2.2 (1.8-2.8)	Cancer	38	1350.4	1.2 (0.8-1.7)
Heart disease	24	90.5	5.1 (3.1-8.4)	Heart disease	114	397.8	3.5 (2.8-4.3)	Heart disease	36	1279.3	1.4 (0.9-2.1)
Psychoactive substance use disorder	24	90.5	22.1 (14.0-34.9)	Drug overdose	80	279.1	17.5 (13.6-22.5)	Chronic lower respiratory disease	5	177.7	0.9 (0.3-2.5)
HIV	21	79.2	17.3 (10.1-29.8)	Psychoactive substance use disorder	59	205.9	19.6 (14.6-26.4)	Cerebrovascular disease	4	142.1	0.7 (0.2-2.5)
Suicide	15	56.6	7.1 (4.2-11.8)	Liver disease	58	202.4	7.7 (5.7-10.3)	Sepsis	4	142.1	1.1 (0.3-5.0)
All causes	252	950.1	8.6 (7.4-9.9)	All causes	670	2337.7	4.5 (4.1-4.9)	All causes	114	4051.3	1.1 (0.9-1.4)
Women											
Drug overdose	28	172.6	23.6 (15.2-36.6)	Cancer	28	326.4	1.9 (1.1-3.1)	Cancer	6	672.4	1.3 (0.5-3.0)
Heart disease	8	49.3	3.6 (1.2-11.1)	Heart disease	16	186.5	3.0 (1.5-6.1)	Heart disease	4	448.3	1.1 (0.4-3.2)
HIV	7	43.1	9.7 (2.9-32.4)	Drug overdose	14	163.2	21.2 (11.4-39.5)	Diabetes mellitus	3	336.2	5.8 (1.5-22.1)
Psychoactive substance use disorder	7	43.1	33.0 (13.0-83.7)	Liver disease	12	139.9	16.9 (9.2-30.9)	Suppressed[c]			
Liver disease	6	37.0	21.3 (8.4-53.9)	HIV	8	93.3	18.0 (6.1-52.5)	Suppressed[c]			
All causes	95	585.6	9.6 (7.4-12.4)	All causes	126	1469.0	4.5 (3.6-5.6)	All causes	21	2353.4	1.1 (0.7-1.8)

Abbreviations: CR, crude rate; HIV, human immunodeficiency virus.
[a] Deaths per 100 000 person-years of observation.
[b] Mortality RRs were calculated by dividing the race-adjusted mortality rates for the homeless cohort by the corresponding mortality rates in the general population of Massachusetts during the same years (2003-2008). Race adjustment was performed using direct standardization to match the racial and ethnic breakdown of the specified age and sex groups within the general population of Massachusetts.
[c] Suppressed owing to confidentiality concerns.

Cancer and heart disease were also major causes of death, each accounting for about 16% of deaths (Table 2). Malignant neoplasms of the trachea, bronchus, and lung comprised over one-third of all cancer deaths. Psychoactive substance use disorders caused nearly 8% of all deaths, and 72% of these were attributable to alcohol.

MORTALITY RATE RATIOS BY AGE AND SEX

Drug overdose was the leading cause of death among 25- to 44-year-old homeless men and women, accounting for 35% of deaths at rates 16- to 24-fold higher than those in the Massachusetts general population (**Table 3**). All-cause mortality rates for men and women in this age group were 8.6- and 9.6-fold higher than in the general population, respectively.

Cancer and heart disease were the leading causes of death among 45- to 64-year-old homeless adults, and the mortality rates for these causes were about 2- and 3-fold higher than in the general population, respectively. All-cause mortality rates in this age group were 4.5-fold higher than in the general population. Among 65- to 84-year-olds, overall and cause-specific mortality rates generally were not significantly different than in comparably aged adults in Massachusetts.

COMPARISON WITH 1988-1993 COHORT

The age-, sex-, and race-standardized mortality rate among 18- to 64-year-old adults in the current study was not significantly different than in the 1988-1993 BHCHP cohort (**Figure 1**). However, there were significant differences with respect to specific causes of death. A 3-fold increase in drug overdose deaths and a 2-fold increase in suicide deaths contributed to an 83% higher rate of deaths due to external causes in comparison with the 1988-1993 cohort. Despite a 2-fold increase in deaths due to psychoactive substance use disorders, significant reductions in deaths due to HIV and cirrhosis contributed to a 15% overall decrease in natural causes of death.

RACIAL VARIATIONS IN MORTALITY

White men had a significantly higher age-standardized mortality rate than black men (rate ratio [RR], 1.94 [95% CI, 1.66-2.28]) and Hispanic men (RR, 1.80 [95% CI, 1.47-2.21]). The age-standardized mortality rate in white women was substantially higher than in Hispanic women (RR, 3.81 [95% CI, 2.19-6.61]) and marginally higher than in black women (RR, 1.31 [95% CI, 0.99-1.74]). **Figure 2** juxtaposes these rates with those expected in the Massachusetts general population if it had the same age distribution as the homeless cohort.

COMMENT

Drug overdose was the leading cause of death in this cohort of currently and formerly homeless adults, occurring at substantially higher rates than in the Massachusetts general population. Despite comprising only 0.3% of the state's adult population, the study cohort accounted for 5% of all drug overdose deaths among Massachusetts adults in 2003 to 2008. Opioids contributed to over 80% of these deaths. Cancer and heart disease were the leading causes of death
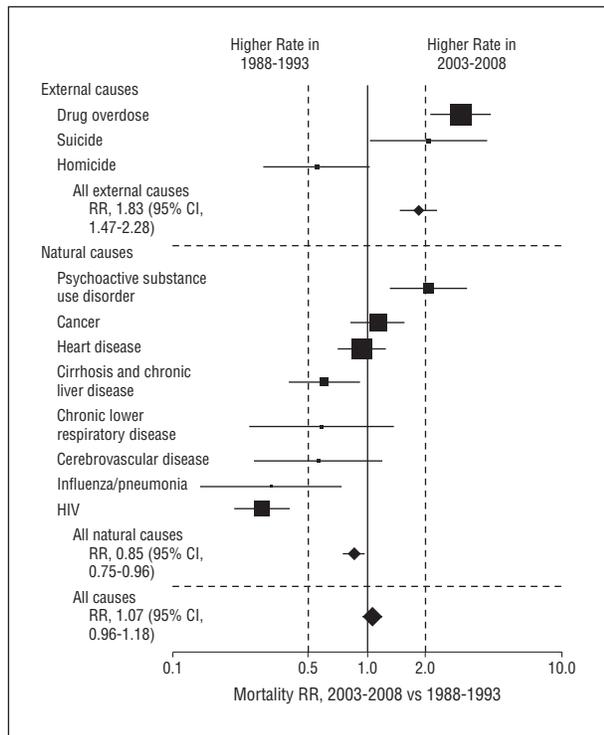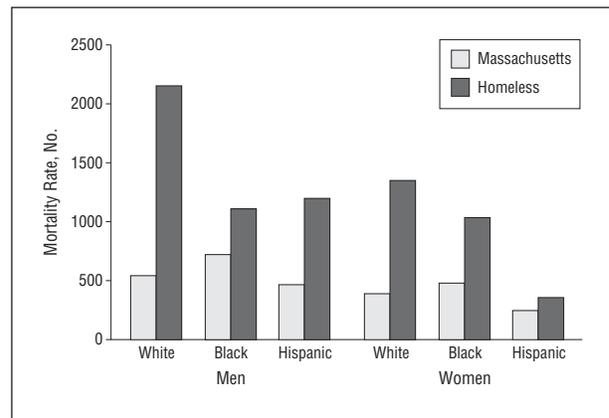
Figure 1. Mortality rate ratios (RRs) comparing cause-specific and overall mortality rates for the 2003-2008 and 1988-1993 homeless cohorts. Boxes are weighted in proportion to the total number of deaths owing to the specified cause. Prior to computing RRs, mortality rates from the 2003-2008 cohort were directly standardized to the age, sex, and race distribution of the 1988-1993 cohort. Differences between *International Classification of Diseases, Ninth Revision (ICD-9)* (1988-1993) and *ICD-10* (2003-2008) underlying cause of death codes were accounted for using comparability ratios from the National Center for Health Statistics. See the eTable for *ICD-9* and *ICD-10* codes and comparability ratios (http://www.jamainternalmed.com). HIV indicates human immunodeficiency virus.

Figure 2. Race-specific age-standardized mortality rates for homeless adults and adults in the general population of Massachusetts (2003-2008), stratified by sex. Mortality rate is expressed as the number of deaths per 100 000 person-years of observation for the homeless cohort, and deaths per 100 000 for the Massachusetts general population. All mortality rates are directly standardized to match the age distribution of the homeless cohort using the following categories: 18 to 24, 25 to 34, 35 to 44, 45 to 54, 55 to 64, and 65 years or older. Owing to limitations in state data, the age-specific mortality rate for 20- to 24-year-old Massachusetts adults was used to estimate the rate for 18- to 24-year-old adults.

among adults 45 years or older. In comparison with the general population, the greatest disparities in all-cause mortality occurred in the younger age groups.

There was no significant difference between the all-cause mortality rate in the 2003-2008 cohort compared with the 1988-1993 cohort. A 15% reduction in deaths owing to natural causes was offset by an 83% increase in deaths due to external causes. Although HIV-related deaths decreased considerably, we found a 3-fold increase in drug overdose deaths and 2-fold increases in deaths due to suicide and psychoactive substance use disorders.

Similar to findings in prior studies,[6,12,18] we found significantly higher mortality rates among white homeless adults in comparison with other racial groups, which differs from the pattern in the general population. This may reflect underlying racial differences in the pathways to homelessness. Evidence suggests that African Americans are more likely to be homeless because of structural factors, such as discrimination and poverty, while homelessness among whites is more heavily linked to personal factors such as mental illness, trauma, family dysfunction, and substance abuse,[34-36] placing these individuals at higher risk of death. This is supported by the finding that whites accounted for a particularly disproportionate percentage of deaths due to drug overdose (68%), substance use disorders (68%), and suicide (89%).

Our findings have implications for policymakers, public health professionals, and clinicians serving this population. The overall mortality pattern of homeless adults in this study demonstrates the substantial impact of substance abuse and mental illness, highlighting the need for integrated systems of care to address these complex issues. Interval increases in deaths due to drug overdose, psychoactive substance use disorders, and suicide suggest that chemical dependency counselors, psychiatrists, and other behavioral health specialists should be collocated with primary care practitioners serving this population. The dramatic rise in drug overdose deaths reflects a broader nationwide trend in drug poisoning mortality fueled largely by rising opioid-related deaths.[37-39] Such deaths are fundamentally preventable. The bulk of opioid overdoses were due to nonheroin substances, including opioid analgesics and other narcotics. Given the high prevalence of both chronic pain and addiction in homeless persons,[40] health care organizations serving this population may wish to develop standardized pain management protocols to help ensure safe, effective, and appropriate opioid prescribing. Efforts to curb prescription drug diversion should remain a national policy priority. Public health initiatives aiming to prevent and reverse opioid overdoses through education and the distribution of intranasal naloxone may also help reduce these deaths.[41,42] In addition to methadone maintenance programs, office-based buprenorphine treatment seems to be feasible in the setting of homelessness[43] and may be an effective option for addressing opioid dependence in this population.

The impact of alcohol and tobacco use is also apparent. Alcohol was the principal substance implicated in 72% of deaths owing to psychoactive substance use disorders and was a co-occurring substance in one-third of drug overdose deaths. The preponderance of deaths due to heart disease and cancer, particularly neoplasms of the trachea, bronchus, and lung, suggests a pressing need to address the 73% prevalence of cigarette smoking among homeless

adults.[44] The heavy burden of such deaths among the growing subset of individuals 45 years or older reinforces the need for primary care and preventive services that target the health issues of an aging homeless population.[45]

From 1988 to 2008, BHCHP substantially expanded the scope of its clinical services in greater Boston.[20] While causality cannot be determined, this expansion may partially explain the interim reduction in natural causes of death that may be more amenable to medical interventions than external causes. However, the lack of change in all-cause mortality is consistent with the fact that multiple factors other than health care influence population health.[46] Addressing the substantial mortality disparities in homeless populations will require not only clinical innovation and tailored health care services, but also creative public health programming combined with policy initiatives to address homelessness and other social determinants of health.

This study has certain limitations. We focused on adults who used Health Care for the Homeless clinical services in Boston. Our findings may not be generalizable to homeless individuals who avoid such services or to homeless adults in other cities. Our study included both currently and formerly homeless adults, which likely exerts a conservative bias on our findings since individuals who have exited homelessness may have lower mortality rates.[18] Finally, the accuracy of death certificates in identifying cause of death has been debated.[47] Death certificates have poor sensitivity but high specificity for identifying drug poisoning deaths,[48] implying a low likelihood for "false-positive" drug overdose deaths in our study. Death certificates also seem to be relatively accurate in identifying cancer deaths,[49,50] the second most common cause of death in this study. Furthermore, decedents in this study underwent autopsy at a 6-fold higher rate than decedents in the Massachusetts general population, providing some reassurance that the cause of death information is not less accurate, and may be more accurate, than for nonhomeless individuals.

In conclusion, drug overdose has replaced HIV as the emerging epidemic among homeless adults. While mortality rates due to certain causes have decreased in comparison with rates 15 years prior, we found substantial increases in addiction-related and mental health–related mortality rates among homeless adults, resulting in no overall change in mortality despite a major expansion in clinical services for this population. Findings suggest the need to integrate psychiatric and substance abuse services into primary medical care and to expand public health efforts to curb the growing problem of opioid-related deaths. The mortality disparity between homeless individuals and the general population, particularly among those who are youngest, underscores the need to address the social determinants of health through policy initiatives to eradicate homelessness.

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