Increased mortality among publicly insured participants in the HIV Outpatient Study despite HAART treatment

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\textbf{Objective:} Understanding mortality differences among HIV-infected patients can focus efforts to improve survival.

\textbf{Design:} We evaluated death rates, causes, and associated factors among treated patients in the HIV Outpatient Study (HOPS), a large, prospective, multicenter observational cohort of HIV-infected persons seen at a diverse set of US sites of care.

\textbf{Methods:} Among 3754 HOPS participants seen during 1996–2007 with at least 6 months of follow-up after initiating HAART and receiving HAART at least 75\% of time under observation (‘substantially treated’), we calculated hazard ratios for death using proportional hazards regression models. We also examined death causes and comorbidities among decedents.

\textbf{Results:} Substantially treated participants, followed a median 4.7 years (interquartile range, 2.2–8.5), experienced 331 deaths. In multivariable analyses, higher mortality was associated with an index CD4 cell count less than 200 cells/\textmu l \textit{adjusted hazard ratio (aHR), 2.86; 95\% confidence interval (CI) 1.95–4.21}, older age \textit{(aHR, 1.50 per 10 years; 95\% CI 1.33–1.70)}, \textit{log}_{10} HIV RNA \textit{(aHR, 1.67 per log}_{10}; 95\% CI 1.51–1.85), but not race/ethnicity \textit{(aHR, 0.99 for blacks vs. whites, } P = 0.92). Mortality was increased among publicly insured (PUB) vs. privately insured participants (PRV) when index CD4 cell count was at least 200 cells/\textmu l \textit{(aHR, 2.03; 95\% CI 1.32–3.14)} but not when index CD4 cell count was less than 200 cells/\textmu l \textit{(aHR, 1.3, } P = 0.13). By death cause, PUB had significantly more cardiovascular events and hepatic disorders than PRV. Comorbidities more frequent among PUB vs. PRV decedents included cardiovascular disease, renal impairment, and chronic hepatitis.

\textbf{Conclusion:} Among HAART-treated participants with CD4 cell counts at least 200 cells/\textmu l, PUB experienced higher death rates than PRV. Non-AIDS death and disease causes predominated among publicly insured decedents, suggesting that treatable comorbidities contributed to survival disparities.

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\textbf{Keywords:} HAART, insurance, mortality, race/ethnicity

\textbf{Introduction}

Death rates among HIV-infected persons in the United States decreased dramatically after the introduction of HAART [1]. Although lower and generally stable during the HAART era [1–3] compared with pre-HAART era, mortality rates for HIV-infected adults remain higher than rates for the general population [4]. The benefits of

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HAART are not equally distributed among all groups; observational studies have noted demographic (e.g., sex, race/ethnicity) differences in the stage of HIV disease at clinical presentation [5,6], in HAART use [7], in adherence to clinical care [6,8,9], in responses to therapy including viral suppression [8,10], and in overall survival [3,5,7,11]. Few studies, however, have examined the extent to which survival and causes of death differ among adult HAART recipients who were under observation all or most of the time while prescribed HAART (i.e., ‘substantially treated’). In an era of national healthcare system reform, identification and characterization of disparities in survival, especially disparities that are associated with healthcare payer type or patient demographics (including descriptions of relationships between source of payment for medical care insurance and other socioeconomic variables such as age, ethnicity, income, and occupation) can inform and focus efforts to improve survival and quality of life for HIV-infected persons. In this report, we describe differences in mortality among HIV-infected persons in care and identify factors that may account for such differences.

Methods

Study population and data sources

We analyzed data from the HIV Outpatient Study (HOPS), an ongoing, prospective, observational multicenter study of HIV-infected persons in care, funded by the US Centers for Disease Control and Prevention (CDC) since 1993 [12]. The study protocol is approved annually by the institutional review boards at the CDC and at each participating clinic. The 12 HOPS sites participating in 1996–2007 were in Washington DC, Tampa FL, Denver CO, Oakland CA, San Leandro CA, Chicago IL, Stony Brook NY, and Philadelphia PA, and included academic, public, and private care centers. Participant data collected included laboratory results, clinical diagnoses, treatments, demographics, risk behaviors, and information regarding death events.

For this analysis, we included participants who had at least two clinical visits between 1 January 1996 and 31 December 2007, using HOPS data updated as of 30 September 2009. We defined the baseline date as 1 January 1996 or the date of first HOPS visit thereafter. Observation was censored at whichever of the following occurred first: death, date of last contact plus an additional 180 days, or 31 December 2007. We terminated observation at the end of 2007 to allow adequate time for identification and documentation of deaths. We restricted our analyses to patients who had received HAART continuously for at least 6 months and received HAART for at least 75% of their observation time; we defined these patients as ‘substantially treated’. We excluded from modeling of mortality a small fraction of substantially treated patients who had their healthcare costs paid by investigational studies or unknown payors, or who had ‘other’ race or ethnicity. In addition to the baseline date when follow-up commenced, we defined an ‘index date’ as the date on which a substantially treated participant first completed 6 months of continuous HAART. Vital status was corroborated using the Social Security Death Index. Only deaths occurring within 6 months after last HOPS contact and before 31 December 2007 were considered.

Definitions of variables analyzed

We calculated all-cause crude mortality rates as deaths per 100 person-years (py) of observation stratified by sex, race/ethnicity, and insurance (i.e., primary payer of medical costs). Insurance was categorized as public, private, or other, according to that type documented during at least 75% of visits during observation. We categorized the following as private: health maintenance organizations (HMOs), preferred provider organizations (PPOs), point of service, and private insurance otherwise unspecified. We categorized the following as public: Medicare, Medicaid, Ryan White Care Act/AIDS Drug Assistance Program (ADAP), and public insurance otherwise unspecified. We categorized all other insurance types as other. If a patient had more than two types of insurance and none were in effect for at least 75% of total HOPS visits, or if the primary medical care payer was a clinical research study, we also categorized insurance as other. CD4+ T-lymphocyte count (CD4) at death was defined as the last CD4 cell count obtained during follow-up.

We defined HAART as any one of the following regimens: any three antiretrovirals, one of which was either a protease inhibitor, a nonnucleoside reverse transcriptase inhibitor (NNRTI) or a fusion, integrase, or entry inhibitor; any three nucleoside reverse transcriptase inhibitors, one of which was abacavir or tenofovir (except for the regimens abacavir + tenofovir + lamivudine and didanosine + tenofovir + lamivudine); two full-dose protease inhibitors; a boosted protease inhibitor with either an NNRTI or a fusion inhibitor; or, an integrase inhibitor combined with either a protease inhibitor, NNRTI, entry inhibitor, or fusion inhibitor. If zidovudine and stavudine were present in the same regimen, they were removed from that regimen’s total antiretroviral count due to their known antagonism.

Chronic comorbidities included cardiovascular disease, hypertension, diabetes mellitus, impaired glucose control, dyslipidemia, renal disorders, chronic obstructive pulmonary disease, hepatitis C virus (HCV) infection, chronic hepatitis B virus (HBV) infection, non-AIDS-defining cancers, and obesity. Obesity was defined as a BMI at least 30 kg/m². Chronic comorbidities were defined based on the presence of diagnoses, treatments, procedures, or laboratory values pertinent to each condition (detailed
A patient was defined as HCV-infected if the medical record contained a positive result for HCV serology, or a report of a detectable HCV plasma viral load or an HCV genotype. A patient was defined as chronically HBV-infected if there was a positive test for serum HBV surface antigen, serum HBV e-antigen, or detectable plasma HBV DNA. Nadir CD4 was the lowest value prior to or within 7 days after the index date. Index CD4 and HIV RNA were the values closest to the index date measured within 6 months prior to or within 7 days after the index date. HIV resistance testing included both genotype and phenotype tests. All variables were defined as of the index date except for HIV resistance testing, which was analyzed as a time-varying variable from the index date.

Patients of Hispanic ethnicity were categorized as Hispanic, regardless of race. Patients of non–Hispanic ethnicity and black or white race were classified as non–Hispanic blacks and non–Hispanic whites, respectively. All other races and unspecified ethnicities were classified as ‘other’ for race.

**Statistical analyses**

Differences in crude mortality rates by race/ethnicity and payor categories and temporal trends in mortality were evaluated using general linear modeling. Continuous variables were compared statistically using the Wilcoxon rank-sum test, and categorical variables using the Pearson $\chi^2$ test. Factors associated with mortality ($P < 0.10$) in univariate proportional hazards regression models were considered for inclusion in multivariable models. If two biologically related factors were strongly associated with each other in exploratory analyses [e.g. history of IDU and HCV infection, nadir CD4 and history of AIDS], we included only one factor in the model, usually the factor for which available data were most complete. We derived final models by manually excluding covariates not statistically or clinically meaningful differences in mortality (race/ethnicity (Fig. 1). Blacks had lower median index CD4 cell counts compared with all other patients (242 vs. 340 cells/μL, $P < 0.0001$), as did publicly insured compared with privately insured patients (242 vs. 340 cells/μL, $P < 0.0001$). Variables significantly associated with increased mortality hazard among substantially treated patients in unadjusted proportional hazards analyses included older age, black race/ethnicity, IDU history, public insurance, AIDS, lower nadir and index CD4 cell count, lower CD4 cell count at HAART initiation, higher index plasma HIV RNA, HCV infection or chronic HBV infection, tobacco smoking history, non-HAART exposure, and having not undergone antiretroviral resistance testing (Table 1).

We also identified an interaction between index CD4 cell count (and CD4 cell count at start of HAART) and insurance: although type of insurance was not associated with mortality rates among participants with CD4 cell
Table 1. Death rates and univariate hazard ratios for mortality by participant characteristics among substantially treated\(^a\) patients observed after index date\(^b\), HIV Outpatient Study, 1996–2007.

| Variable                                      | Substantially treated patients | No. of deaths | No. of patient-years (py) | Deaths per 100 py\(^c\) | Hazard ratio | P      |
|-----------------------------------------------|--------------------------------|---------------|---------------------------|-------------------------|--------------|--------|
| No. of patients                               | 3569                          | 318           | 19,543                    | 1.6                     |              |        |
| Age at index date [years, median (IQR)]       | 39 (34–46)                    |               |                           |                         |              |        |
| Men [no. (%)]                                 | 2996 (84.0)                   | 271           | 16,441                    | 1.6 Referent            |              |        |
| Race [no. (%)]                                | 573 (16.0)                    | 47            | 3,101                     | 1.5                     | 0.92         | 0.58   |
| Non-Hispanic white                            | 2133 (59.8)                   | 187           | 12,395                    | 1.5 Referent            |              |        |
| Non-Hispanic black                            | 1019 (28.6)                   | 100           | 4,970                     | 2.0                     | 1.33         | 0.022  |
| Hispanic                                      | 417 (11.7)                    | 31            | 2,177                     | 1.4                     | 0.94         | 0.75   |
| HIV transmission risk [no. (%)]               | 2265 (63.5)                   | 178           | 12,733                    | 1.4 Referent            |              |        |
| MSM                                           | 2265 (63.5)                   | 178           | 12,733                    | 1.4 Referent            |              |        |
| High-risk heterosexual contact                 | 776 (21.7)                    | 67            | 4,084                     | 1.6                     | 1.17         | 0.28   |
| IDU                                           | 346 (9.7)                     | 54            | 1,797                     | 3.0                     | 2.15         | <0.0001 |
| Other                                         | 182 (5.1)                     | 19            | 928                       | 2.0                     | 1.47         | 0.11   |
| Insurance/payor [no. (%)]                     |                               |               |                           |                         |              |        |
| Private                                       | 2020 (56.6)                   | 137           | 11,523                    | 1.2                     | Referent     |        |
| Public                                        | 1146 (32.1)                   | 143           | 5,711                     | 2.5                     | 2.11         | <0.0001 |
| Other                                         | 403 (11.3)                    | 38            | 2,309                     | 1.6                     | 1.39         | 0.07   |
| History of AIDS [no. (%)]                     |                               |               |                           |                         |              |        |
| No                                            | 1362 (38.2)                   | 60            | 7,554                     | 0.8                     | Referent     |        |
| Yes                                           | 2207 (61.8)                   | 258           | 11,988                    | 2.2                     | 2.74         | <0.0001 |
| Nadir CD4 cell count at index [cells/\(\mu l\), median (IQR)] (\(n = 3034\)) | 180 (52–327) |               |                           |                         |              |        |
| CD4 cell count at index date [cells/\(\mu l\), median (IQR)] (\(n = 2799\)) | 295 (160–475) |               |                           |                         |              |        |
| CD4 cell count at index date [no. (%)]         |                               |               |                           |                         |              |        |
| \(\geq 200\) cells/\(\mu l\)                  | 1890 (53.0)                   | 113           | 10,476                    | 1.1                     | Referent     |        |
| <200 cells/\(\mu l\)                          | 909 (25.5)                    | 155           | 4,445                     | 3.5                     | 3.24         | <0.0001 |
| Unknown                                       | 770 (21.6)                    | 50            | 4,622                     | 1.1                     | 1.00         | 0.95   |
| CD4 cell count at HAART initiation [no. (%)]   |                               |               |                           |                         |              |        |
| \(\geq 200\) cells/\(\mu l\)                  | 1124 (31.5)                   | 59            | 6,628                     | 0.9                     | Referent     |        |
| <200 cells/\(\mu l\)                          | 1011 (28.3)                   | 135           | 5,492                     | 2.5                     | 2.77         | <0.0001 |
| Unknown                                       | 1434 (40.2)                   | 124           | 7,423                     | 1.7                     | 1.87         | <0.0001 |
| HIV RNA log_{10} copies/ml at index date [median (IQR)] (\(n = 2765\)) | 2.3 (1.7–3.4) |               |                           |                         |              |        |
| Achieved undetectable plasma HIV RNA before index date [no. (%)] |                               |               |                           |                         |              |        |
| Yes                                           | 2103 (58.9)                   | 212           | 11,173                    | 1.9                     | Referent     |        |
| No                                            | 1466 (41.1)                   | 106           | 8,370                     | 1.3                     | 0.67         | 0.0007 |
| Achieved undetectable plasma HIV RNA before end of observation [no. (%)] |                               |               |                           |                         |              |        |
| Yes                                           | 857 (24.0)                    | 139           | 2,832                     | 4.9                     | Referent     |        |
| No                                            | 2712 (76.0)                   | 179           | 16,711                    | 1.1                     | 0.21         | <0.0001 |
| Chronic HBV infection [no. (%)]                |                               |               |                           |                         |              |        |
| No                                            | 3422 (95.9)                   | 298           | 18,741                    | 1.6                     | Referent     |        |
| Yes                                           | 147 (4.1)                     | 20            | 801                       | 2.5                     | 1.58         | 0.048  |
| Chronic HCV infection [no. (%)]                |                               |               |                           |                         |              |        |
| No                                            | 3208 (89.9)                   | 267           | 17,778                    | 1.5                     | Referent     |        |
| Yes                                           | 361 (10.1)                    | 51            | 1,765                     | 2.9                     | 1.93         | <0.0001 |
| Chronic HBV or HCV infection [no. (%)]         |                               |               |                           |                         |              |        |
| No                                            | 3090 (86.6)                   | 253           | 17,128                    | 1.5                     | Referent     |        |
| Yes                                           | 479 (13.4)                    | 65            | 2,414                     | 2.7                     | 1.83         | <0.0001 |
| History of tobacco use [no. (%)]               |                               |               |                           |                         |              |        |
| Never                                         | 1656 (46.4)                   | 121           | 9,203                     | 1.3                     | Referent     |        |
| Current or prior use                           | 1913 (53.6)                   | 197           | 10,339                    | 1.9                     | 1.45         | 0.001  |
| History of substance use [no. (%)]             |                               |               |                           |                         |              |        |
| No                                            | 2446 (68.5)                   | 206           | 13,431                    | 1.5                     | Referent     |        |
| Yes                                           | 1123 (31.5)                   | 112           | 6,111                     | 1.8                     | 1.20         | 0.13   |
| Year of HAART initiation [no. (%)]             |                               |               |                           |                         |              |        |
| <2000                                         | 2394 (67.1)                   | 279           | 15,618                    | 1.8                     | Referent     |        |
| \(\geq 2000\)                                  | 1175 (32.9)                   | 39            | 3,925                     | 1.0                     | 0.54         | 0.0004 |
| Antiretroviral exposure before index date [no. (%)] |                               |               |                           |                         |              |        |
| HAART-only                                     | 1269 (35.6)                   | 66            | 6,092                     | 1.1                     | Referent     |        |
| Any non-HAART                                  | 1690 (47.4)                   | 206           | 10,747                    | 1.9                     | 1.80         | <0.0001 |
| Unknown/incomplete ARV history                 | 610 (47.9)                    | 46            | 2,703                     | 1.7                     | 1.58         | 0.02   |
count less than 200 cells/μl, participants with public insurance had a higher mortality hazard than those with private insurance when their index CD4 cell count (or CD4 cell count at start of HAART) was at least 200 cells/μl (Table 2).

Table 3 outlines patient characteristics among substantially treated persons with baseline CD4 cell count at least 200 cells/μl, stratified by insurance type. In this group, compared to persons with private insurance, persons with public insurance were more likely ($P < 0.001$) to be women, Hispanic or non-Hispanic black race, have HRH risk for HIV, have a history of IDU, any recreational substance use, have a history of AIDS, chronic HCV infection, tobacco use, or to be cared for in a university clinic. Persons in this group with public insurance were less likely ($P < 0.001$) to ever achieve an undetectable plasma HIV RNA level, to be seen in a group practice setting, or to undergo HIV resistance testing ($P = 0.006$).

In adjusted models (Table 4) with interaction terms between index CD4 cell count and insurance, or between CD4 cell count at start of HAART and insurance, we also found increased mortality hazard among older patients, injection drug users compared with MSM, and persons with higher index HIV RNA levels; and reduced hazard for participants who underwent HIV resistance testing. Among patients with index CD4 cell count at least 200–cells/μl, those with private insurance had significantly higher hazard of death than those with private insurance [adjusted hazard ratio (aHR), 2.03; 95% confidence interval (CI) 1.32–3.14]; type of insurance was not associated with mortality hazard among patients with CD4 cell count less than 200 cells/μl.

In another model, not presented here, we investigated whether insurance status remained associated with increased mortality among substantially treated participants if it was defined as of the index date rather than as the predominant insurance type during the study observation period. In this model, publicly insured participants still had higher mortality rates than privately insured participants (aHR, 3.14; 95% CI, 1.96–5.04) when index CD4 cell count was at least 200 cells/μl. When the model controlled for CD4 cell count at HAART initiation instead of index CD4 cell count (for the smaller subset of participants who had that...
measurement available), mortality hazard for publicly compared with privately insured participants remained elevated but was not statistically significant (aHR, 1.36; 95% CI 0.95–1.95).

Among substantially treated patients, 87% of the publicly insured and 89% of the privately insured remained covered by the same insurance/payor type during their entire observation. Of 2020 patients in the private insurance/payor group, only 2% had public or other/unknown insurance at their last visit; of 1146 persons in the public insurance/payor group, 1.4% had private or other/unknown insurance at their last visit.

Causes of death were available for 248 (78%) of participants who died: 77% of privately insured participants, 76% of publicly insured participants, 81% of whites, 69% of blacks, and 87% of Hispanics. Blacks were less likely than all other race/ethnicities to have a documented cause of death ($P = 0.025$). Among participants with causes of death reported (Table 5), publicly insured participants had proportionately more ($P < 0.05$) deaths than privately insured patients from cardiovascular events (30.3 vs. 15.1%) and hepatic disorders (23.8 vs. 12.3%). Compared with whites, deaths among blacks were more likely ($P < 0.05$) to involve cardiovascular events (31.9 vs. 19.7%) and renal disease (23.2 vs. 6.6%). In analyses of chronic non-AIDS comorbidities among participants who died (Table 6), publicly insured compared with privately insured participants were more likely to have ($P < 0.05$) cardiovascular disease (25.9 vs. 13.1%), renal disease (24.5 vs. 13.1%), and HCV or chronic HBV infection (48.2 vs. 17.5%). Compared with whites, blacks were more likely ($P < 0.05$) to have had HCV or chronic HBV infection (38.0 vs. 26.2%) or to have ever been obese (26.0 vs. 13.4%).

Finally, for comparison with data for decedents, we undertook further analyses of all substantially treated HOPS participants with index CD4 cell counts at least 200 cells/$\mu l$ and found that publicly insured participants were more likely ($P < 0.05$) than privately insured participants to have HCV or chronic HBV infection (28.5 vs. 8.5%), hypertension (35.3 vs. 18.7%), cardiovascular disease (6.8 vs. 2.2%), diabetes (6.8 vs. 2.3%), and chronic obstructive pulmonary disease (5.8 vs. 1.2%) at index date.

### Discussion

In this large prospective observational study of a diverse cohort of HIV-infected patients seen in the United States during the contemporary HAART era, substantially HAART-treated patients with a CD4 cell count of at least 200 cells/$\mu l$ whose principal access to medical care payment was through publicly funded sources experienced a greater than two-fold adjusted mortality rate compared with similar patients whose healthcare costs were paid by private entities. Significant differences in adjusted mortality rates by payor among similar patients with CD4 cell count less than 200 cells/$\mu l$ were not apparent.
Table 3. Characteristics of substantially treated\(^a\) patients with index\(^b\) CD4 cell count greater than or equal to 200 cells/\(\mu\)l by insurance status\(^c\), HIV Outpatient Study, 1996–2007.

| Characteristic | Total | Private | Public | Other/unknown | \(P\) |
|----------------|-------|---------|--------|---------------|-------|
| No. of patients | 1890  | 1159    | 313    | 218           |       |
| Age at index date [years, median (IQR)] | 40 (34–46) | 39 (34–45) | 41 (35–48) | 41 (35–47) | 0.0001 |
| Deaths | 113 (6.0) | 50 (4.3) | 48 (9.4) | 15 (6.9) | 0.0003 |
| Sex | Male | 1599 (84.6) | 1082 (93.4) | 334 (65.1) | 183 (83.9) |
|      | Female | 291 (15.4) | 77 (6.6) | 179 (34.9) | 35 (16.1) |
| Race | Non-Hispanic white | 1197 (63.3) | 887 (76.5) | 184 (35.9) | 126 (57.8) |
|      | Non-Hispanic black | 491 (26.0) | 188 (16.2) | 242 (47.2) | 61 (28.0) |
|      | Hispanic | 202 (10.7) | 84 (7.2) | 87 (17.0) | 31 (14.2) |
| HIV transmission risk | MSM | 1262 (66.8) | 967 (83.4) | 164 (32.0) | 131 (60.1) |
|      | High-risk heterosexual contact | 381 (20.2) | 121 (10.4) | 208 (40.6) | 52 (23.8) |
|      | IDU | 161 (8.5) | 35 (3.0) | 107 (20.9) | 19 (8.7) |
|      | Other | 86 (4.6) | 36 (3.1) | 34 (6.6) | 16 (7.3) |
| History of AIDS | No | 937 (49.6) | 640 (55.2) | 196 (38.2) | 101 (46.3) |
|      | Yes | 953 (50.4) | 519 (44.8) | 317 (61.8) | 117 (53.7) |
| Achieved undetectable plasma HIV RNA before index date | No | 828 (43.8) | 465 (40.1) | 266 (51.8) | 97 (44.5) |
|      | Yes | 1062 (56.2) | 694 (59.9) | 247 (48.2) | 121 (55.5) |
| Achieved undetectable plasma HIV RNA before end of observation | No | 303 (16.0) | 150 (12.9) | 113 (22.0) | 40 (18.4) |
|      | Yes | 1587 (84.0) | 1009 (87.1) | 400 (78.0) | 178 (81.6) |
| Chronic HBV infection | No | 1807 (95.6) | 1113 (96.0) | 487 (94.9) | 207 (95.0) |
|      | Yes | 83 (4.4) | 46 (4.0) | 26 (5.1) | 11 (5.0) |
| Chronic HCV infection | No | 1685 (89.2) | 1105 (95.3) | 384 (74.8) | 196 (89.9) |
|      | Yes | 205 (10.8) | 54 (4.7) | 129 (25.2) | 22 (10.1) |
| Chronic HBV or HCV infection | No | 1616 (85.0) | 1061 (91.5) | 367 (71.5) | 188 (86.2) |
|      | Yes | 274 (14.5) | 98 (8.5) | 146 (28.5) | 30 (13.8) |
| History of tobacco use | Never | 854 (45.2) | 612 (52.8) | 159 (31.0) | 83 (38.1) |
|      | Current or prior use | 1036 (54.8) | 547 (47.2) | 354 (69.0) | 135 (61.9) |
| History of substance use | No | 1288 (68.2) | 889 (76.7) | 261 (50.9) | 138 (63.3) |
|      | Yes | 602 (31.8) | 270 (23.3) | 252 (49.1) | 80 (36.7) |
| Year of HAART initiation | <2000 | 1246 (65.9) | 775 (66.9) | 316 (61.6) | 155 (71.1) |
|      | \(\geq\)2000 | 644 (34.1) | 384 (33.1) | 197 (38.4) | 63 (28.9) |
| Non-HAART exposure before index date | No | 667 (35.3) | 417 (36.0) | 165 (32.2) | 85 (39.0) |
|      | Yes | 923 (48.8) | 573 (49.4) | 241 (47.0) | 109 (50.0) |
|      | Unknown | 300 (15.9) | 169 (14.6) | 107 (20.9) | 24 (11.0) |
| Non-HAART exposure before end of observation | No | 589 (31.2) | 382 (33.0) | 140 (27.3) | 67 (30.7) |
|      | Yes | 1028 (54.4) | 623 (53.8) | 276 (53.8) | 129 (59.2) |
|      | Unknown | 273 (14.4) | 154 (13.5) | 97 (18.9) | 22 (10.1) |
| Underwent HIV ARV resistance testing before index date | No | 1600 (84.7) | 970 (83.7) | 433 (84.4) | 197 (90.4) |
|      | Yes | 290 (15.3) | 189 (16.3) | 80 (15.6) | 21 (9.6) |
| Underwent HIV ARV resistance testing before end of observation | No | 1184 (62.6) | 741 (63.9) | 294 (57.3) | 149 (68.4) |
|      | Yes | 706 (37.4) | 418 (36.1) | 219 (42.7) | 69 (31.6) |
| Type of site | Non-university based clinic | 225 (11.9) | 159 (13.7) | 36 (7.0) | 30 (13.8) |
|      | Group practice | 870 (46.0) | 654 (56.4) | 137 (26.7) | 79 (36.2) |
|      | University clinic | 795 (42.1) | 346 (29.8) | 340 (66.3) | 109 (50.0) |

ARV, antiretroviral; HBV, hepatitis B virus; HCV, hepatitis C virus; IQR, interquartile range.

\(^{a}\)Patients were considered substantially treated if they received at least 6 months of continuous HAART and received HAART during at least 75% of their observation time following baseline.

\(^{b}\)Index date was the date at which 6 months of continuous HAART first completed and when observation for death outcome begins.

\(^{c}\)Insurance status was classified according to the payor status in effect during at least 75% of visits.
these adjusted analyses, race/ethnicity was not associated with increased mortality once CD4 cell counts, insurance/payor, and other factors were taken into account. Among participants who died, several modifiable comorbid conditions and related causes of death were more prevalent among publicly than privately insured participants and among blacks than whites.

Our decision to focus this analysis on substantially treated patients was based upon preliminary findings (data not shown) of marked differences in the prevalence and persistence of HAART use among patient groups (e.g., publicly insured compared with privately insured, blacks compared with whites). We sought to minimize the impact of differential HAART exposure by evaluating more optimally treated patients. The substantially treated group differed from the overall cohort (see Acknowledgements section); in the substantially treated group, there was a somewhat lower proportion of black and publicly insured patients, median baseline and nadir CD4 were lower, and there was a higher prevalence of AIDS.

Table 4. Risk of mortality in association with selected variables among substantially treated participants in the HIV Outpatient Study, Cox proportional modeling results, 1996–2007.

| Variable                                      | Using CD4 cell count at index date* (n = 2674, no. of events = 250) | Using CD4 cell count at HAART initiation (n = 1944, no. of events = 178) |
|-----------------------------------------------|---------------------------------------------------------------------|-----------------------------------------------------------------------|
|                                               | Adjusted hazard ratio (95% CI) | P                                 | Adjusted hazard ratio (95% CI) | P                                 |
| Age at index date (per 10-year increments)   | 1.50 (1.33–1.70)              | <0.0001                           | 1.53 (1.32–1.76)              | <0.0001                           |
| Sex                                           | Male Referent                  |                                    | Female Referent               | 0.75 (0.48–0.18)                 | 0.21                               |
| Race                                          | Non-Hispanic white Referent    |                                    | Non-Hispanic black 0.99 (0.72–1.34) | 0.92                           |
| HIV transmission risk                          | Male sex with male Referent    |                                    | Non-Hispanic black 0.99 (0.72–1.34) | 0.92                           |
| CD4 at index date                              | 1.50 (1.33–1.70)              | <0.0001                           | 1.53 (1.32–1.76)              | <0.0001                           |
| Other HIV transmission risk                    | 1.34 (0.79–2.27)              | 0.28                              | 1.34 (0.79–2.27)              | 0.28                              |
| CD4 <200 cells/µl at index date               | Referent 2.86 (1.95–4.21)     | <0.0001                           | Referent 2.86 (1.95–4.21)     | <0.0001                           |
| Overall interaction between CD4 at index date  | 0.13                               |                                    | 0.13                               |                                    |
| and insurance/payor                           | Private 2.03 (1.32–3.14)       | 0.001                             | Private 2.03 (1.32–3.14)       | 0.001                             |
| CD4 ≥200 cells/µl and insurance               | Other 1.37 (0.76–2.47)         | 0.29                              | Other 1.37 (0.76–2.47)         | 0.29                              |
| CD4 <200 cells/µl at index date               | Referent 1.18 (0.81–1.73)      | 0.39                              | Referent 1.18 (0.81–1.73)      | 0.39                              |
| Overall interaction between CD4 at index date  | Other 0.89 (0.53–1.49)         | 0.65                              | Other 0.89 (0.53–1.49)         | 0.65                              |
| and insurance/payor                           | CD4 ≥200 cells/µl at HAART initiation |                      | CD4 <200 cells/µl at HAART initiation | 3.41 (2.04–5.68) | <0.0001 |
| CD4 <200 cells/µl at HAART initiation         | Referent --                    |                                    | Referent --                    |                                    |
| Overall interaction between CD4 at HAART      | CD4 ≥200 cells/µl and insurance |                      | CD4 ≥200 cells/µl and insurance | --                               |
| initiation and insurance/payor                | Private Referent               | --                                | Private Referent               | --                                |
| CD4 <200 cells/µl and insurance               | Public 3.00 (1.61–5.60)        | 0.0005                            | Public 3.00 (1.61–5.60)        | 0.0005                            |
| CD4 <200 cells/µl at index date               | Other 1.70 (0.77–3.76)         | 0.19                              | Other 1.70 (0.77–3.76)         | 0.19                              |
| Log_{10} HIV RNA (viral load) at index date   | Referent 1.03 (0.61–1.72)      | 0.92                              | Referent 1.03 (0.61–1.72)      | 0.92                              |
| Year of HAART initiation                      | <2000 Referent                 | --                                | <2000 Referent                 | --                                |
| CD4 ≥2000                                     | 0.78 (0.52–1.56)               | 0.21                              | 0.78 (0.52–1.56)               | 0.21                              |
| CD4 <2000                                     | 0.39 (0.29–0.52)               | <0.0001                           | 0.39 (0.29–0.52)               | <0.0001                           |
| Underwent HIV antiretroviral resistance testing | (time varying factor)         |                                    | (time varying factor)         |                                    |

CI, confidence interval.

*Index date was the date at which 6 months of continuous HAART first completed and when observation for death outcome begins. Persons with missing index viral loads were excluded.
Table 5. Causes of death among substantially treated\textsuperscript{a} participants for whom at least one cause of death was reported\textsuperscript{b}, by race and payor, HIV Outpatient Study, 1996–2007.

| Race                  | Deaths (N) | AIDS | Bacteremia/ sepsis | Cardiovascular events | GI disorders | Hematologic disorders | Hepatic disorders | Cancer (non-AIDS) | Neurologic disorders | Pulmonary disease | Renal disease |
|-----------------------|------------|------|--------------------|-----------------------|--------------|-----------------------|-------------------|-------------------|---------------------|-----------------|--------------|
| Overall               | 248        | 131  | 52.8               | 30 12.1               | 57 23.0      | 31 12.5               | 11 4.4            | 41 16.5          | 22 8.9             | 48 19.4         | 29 11.7      |
| White                 | 152        | 87   | 57.2               | 14 9.2                | 30 19.7      | 17 11.2               | 6 4.0             | 23 15.1          | 22 14.5            | 14 9.2          | 30 19.7      |
| Black                 | 69         | 30   | 43.5               | 10 14.5               | 22 31.9      | 12 17.4               | 4 5.8             | 12 17.4          | 7 10.1             | 6 8.7           | 10 14.5      |
| Hispanic              | 27         | 14   | 51.8               | 6 22.2                | 5 18.5       | 2 7.4                 | 1 3.7             | 6 22.2            | 2 7.4              | 8 2.9           | 3 11.1       |
| Across races          |            |      |                    |                       |              |                       |                   |                   |                     |                 |             |
| Overall               | P = 0.16\textsuperscript{c} | P = 0.12 | P = 0.12 | P = 0.30 | P = 0.81 | P = 0.64 | P = 0.46 | P = 0.95 | P = 0.24 | P = 0.002 |
| White                 | P = 0.58   | P = 0.24 | P = 0.048 | P = 0.20 | P = 0.54 | P = 0.67 | P = 0.38 | P = 0.90 | P = 0.35 | P = 0.0004 |
| Black                 | P = 0.12   | P = 0.73 | P = 0.01 | P = 0.74 | P = 0.55 | P = 0.03 | P = 0.05 | P = 0.51 | P = 0.57 | P = 0.08  |

Table 6. Comorbidities among substantially treated\textsuperscript{a} participants who died by race and payor, HIV Outpatient Study, 1996–2007.

| Race                  | Deaths (N) | CVD\textsuperscript{b} | Hypertension | Diabetes mellitus | Impaired glucose control | Dyslipidemia | Renal disease | COPD | Cancer (Non-AIDS) | HIV or HCV coinfection | Obesity\textsuperscript{d} |
|-----------------------|------------|-------------------------|-------------|-------------------|--------------------------|--------------|---------------|------|-------------------|--------------------------|------------------|
| Overall               | 248        | 131                     | 52.8        | 30 12.1           | 57 23.0                  | 31 12.5      | 11 4.4        | 41 16.5 | 22 8.9           | 48 19.4                 | 29 11.7         |
| White                 | 152        | 87                      | 57.2        | 14 9.2            | 30 19.7                  | 17 11.2      | 6 4.0         | 23 15.1 | 22 14.5          | 14 9.2                  | 30 19.7         |
| Black                 | 69         | 30                      | 43.5        | 10 14.5           | 22 31.9                  | 12 17.4      | 4 5.8         | 12 17.4 | 7 10.1           | 6 8.7                    | 10 14.5         |
| Hispanic              | 27         | 14                      | 51.8        | 6 22.2            | 5 18.5                   | 2 7.4        | 1 3.7         | 6 22.2  | 2 7.4            | 8 2.9                    | 3 11.1         |
| Across races          |            |                         |             |                   |                          |              |               |       |                  |                          |                 |
| Overall               | P = 0.16\textsuperscript{c} | P = 0.12 | P = 0.12 | P = 0.30 | P = 0.81 | P = 0.64 | P = 0.46 | P = 0.95 | P = 0.24 | P = 0.002 |
| White                 | P = 0.58   | P = 0.24 | P = 0.048 | P = 0.20 | P = 0.54 | P = 0.67 | P = 0.38 | P = 0.90 | P = 0.35 | P = 0.0004 |
| Black                 | P = 0.12   | P = 0.73 | P = 0.01 | P = 0.74 | P = 0.55 | P = 0.03 | P = 0.05 | P = 0.51 | P = 0.57 | P = 0.08  |

COPD, chronic obstructive pulmonary disease; CVD, cardiovascular disease; HBV, hepatitis B virus; HCV, hepatitis C virus; white, non-Hispanic white; black, non-Hispanic black.
\textsuperscript{a}Completed at least 6 continuous months of HAART and received HAART for at least 75% of study observation time.
\textsuperscript{b}Patients could be included in more than one cause of death category (e.g., hepatic and cardiovascular; AIDS and GI disorder); see Methods section for explanation how causes of death were ascertained and classified.
\textsuperscript{c}Pearson $\chi^2$ test was used for three-way and two-way comparisons.
\textsuperscript{d}Ever had a BMI $\geq$ 30 kg/m\textsuperscript{2}.

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The independent association of public insurance with increased mortality risk was noted only in patients with either an index CD4 or a CD4 cell count at HAART initiation at least 200 cells/μL. This finding suggests that the increased risk of death was not a consequence of HIV-related morbidity per se but rather was associated with differences between the two groups in the rates or types of comorbid conditions or differences in the quality of medical care provided. We believe our analysis is the first to document an association between the types of medical coverage to which HIV-infected patients have access and patient survival.

In multivariate models, differences were observed among patients with CD4 cell counts more than or of at least 200 cells/μL when stratified by insurance type, in the prevalence of factors shown to be associated with mortality risk. In univariate models these included hepatitis C virus co-infection (which correlates with IDU and history of substance abuse) and tobacco smoking.

We acknowledge that these factors could have contributed to observed mortality differences between publicly and privately insured persons in this higher CD4 stratum; nevertheless, the independent and significant association of public insurance with increased mortality in adjusted models persisted after adjusting for key variables prognostic of the mortality in the HOPS.

Recent reports indicate that deaths and comorbidities during the contemporary treatment era are less likely to involve AIDS-defining (immunodeficiency-related or opportunistic) illnesses and are increasingly likely to occur as a consequence of complications from chronic non-AIDS comorbidities [2,12–16]. In our cohort, nearly half of deaths were due to non-AIDS causes. Some of the most prevalent non-AIDS causes of death (e.g. cardiovascular, renal, and liver disease) [2] and comorbidities (e.g. viral hepatitis coinfection, obesity) occurred with greater frequency among both publicly insured and black participants who died. Obesity and viral hepatitis coinfection as well as many of the other comorbidities that were differentially increased among publicly insured and black participants represent preventable, often treatable conditions. Hence, timely identification and treatment of comorbidities has emerged as an important component of HIV medical care [17].

We urge caution in interpreting our findings. We believe it would be improper to consider these findings as evidence that the quality of publicly funded healthcare provided was inferior and that it was primarily this inferiority that contributed to the greater mortality observed among publicly insured persons. Although we did not specifically examine the quality of healthcare delivered, our findings have important implications for healthcare reform because the population of persons whose access to healthcare was principally through public sources was significantly enriched in patients diagnosed with comorbidities – usually treatable and often preventable – that are known to be causes of the diseases that predominated as causes of death, especially for the publicly insured. Although the associations between mortality and type of insurance among these HIV-infected adults may have been influenced by subtle differences in the quality of care, none were readily apparent in any comparisons of care indices [e.g., frequency of visits (data not shown)] among privately vs. publicly funded patients at any HOPS site; it is more likely that the mortality/insurance associations were driven by an excess of underlying non-HIV-related comorbid disease among persons whose healthcare was publicly funded. The extent to which having publicly funded healthcare was a marker for socioeconomic issues which themselves engendered greater risk for death (and disease) is unclear.

Our study has limitations. As insurance/payor status was ascertained only at the time of clinic visits, we could not ascertain the precise timing of transition from private to public insurance/payor or vice-versa in the relatively small proportion of patients who had more than one primary payor type while under observation. For the same reason, we could not estimate percentage of follow-up time spent in each insurance category, and instead we assigned insurance/payor category based upon its presence at more than 75% of the visits. We believe that it is unlikely that this impacted our overall findings as the vast majority of patients analyzed had only one insurance/payor type throughout their observation. Furthermore, we could not find evidence that the association between public-coverage and increased mortality among patients with CD4 cell count at least 200 cells/μL was due to a systematic shift of patients from privately to publicly funded health coverage over time in association with advancing age or progression of their HIV disease. Although we adjusted for key variables associated with mortality in our final parsimonious model, unmeasured or other unaccounted for confounders might exist that could explain the association of public insurance with increased mortality among patients with CD4 cell count at least 200 cells/μL. For instance, we lack systematically collected data on antiretroviral adherence, clinical encounter length, missed clinical visits, or comorbid disease prevention counseling administration. Also, we have tried to consider other aspects of care or sociodemographics for which ‘insurance payor’ may be a proxy. Included among these were issues for which did not have sufficient data available to us to specifically address, such as data regarding quality of life or patient income. Indeed, our findings suggest further research is needed to investigate these and other qualitative differences in HIV care that might be payor-based and their causal associations with mortality. Also, information on causes of death was not complete for all patients and could have been inaccurately documented on death.
certificates in some cases, as has been observed in prior studies [18–20].

Nevertheless, important strengths of our analysis include the use of data from a longitudinal observational cohort in which there were sufficient numbers of deaths to allow for relevant comparisons using sociodemographic variables. HOPS patients were cared for in real-world clinical settings (i.e. observations were not derived from clinical trials or interval cohorts) by their own medical care providers and were sufficiently diverse in terms of sex, race/ethnicity, and type of health insurance to permit meaningful analysis of factors that impacted survival.

The extent to which mortality rates among HIV-infected patients treated with HAART can be further reduced by routine and timely screening for and treatment of non-HIV-associated comorbid illnesses is not yet clear. Although it is unknown at present whether such measures should commence at earlier ages for HIV-infected persons than HIV-uninfected persons, as HIV-infected patients live longer the incidence of these conditions will almost certainly increase. Preemptive risk reduction, early detection, and aggressive treatment of chronic comorbid diseases increasingly comprise routine medical care for HIV infection. Adoption of such measures as standard-of-care may bring us closer to ‘closing the gap’ in survival expectancy that exists between diverse populations of HIV-infected persons, and between HIV-infected and HIV-uninfected patients in the United States.

In conclusion, among contemporary HIV-infected US patients substantially treated with HAART whose CD4 cell counts were at least 200 cells/μl, we observed higher mortality among persons whose only access to medical care was through publicly funded sources, compared to persons who received privately funded medical care. After adjusting for type of healthcare insurance and other factors that impact survival, risk of mortality among substantially HAART-treated patients did not differ by race/ethnicity. Further, we found significantly higher frequencies of often preventable chronic comorbid conditions among publicly insured patients who died; however, further research is warranted to characterize how these factors may explain our principal observation. As our nation undergoes healthcare reform, we need to better understand how healthcare delivery and its financial reimbursement affect quality of care (including routine well health screening and preemptive care) and mortality risk, particularly among groups of persons who have higher prevalence of illnesses that ultimately contribute to mortality regardless of insurance status. In the interim, screening for and addressing modifiable health risks associated with preventable and treatable medical conditions should guide clinical practice and inform public health measures in our efforts to further improve survival and enhance overall health for all patients.

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R.K.B. contributed to data collection, analysis and interpretation, and manuscript preparation.

Reproducible Research Statement: Study protocol and statistical code: available from the authors. Data set: the HOPS is a public-use dataset and is available to non-HOPS investigators. However, confidentiality protections that govern the HOPS data require HOPS authors to strip all record identifiers; it will therefore take some time to make these data available if requested. In addition, the CDC’s heightened security procedures require persons who want to analyze HOPS data to prepare a written proposal for CDC review and approval; sign confidentiality and data use agreements; conduct analyses with the CDC in Atlanta; and go through CDC security clearance for access to facilities. The authors would be happy to facilitate these procedures for persons interested in conducting analyses with HOPS project data and welcome these requests.

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Conflicts of interest
No potential conflicts of interest have been identified by any of the authors.

References
1. Palella FJ Jr, Delaney KM, Moorman AC, Loveless MO, Fuhrer J, Satten GA, et al. Declining morbidity and mortality among patients with advanced human immunodeficiency virus infection. HIV Outpatient Study Investigators. N Engl J Med 1998; 338:853–860.
2. Palella FJ Jr, Baker RK, Moorman AC, Chmiel JS, Wood KC, Brooks JT, Holmberg SD. Mortality in the highly active antiretroviral therapy era: changing causes of death and disease in the HIV outpatient study. J Acquir Immune Defic Syndr 2006; 43:27–34.
3. Hessol NA, Kalinowski A, Benning L, Mullen J, Young M, Palella F, et al. Mortality among participants in the Multicenter AIDS Cohort Study and the Women’s Interagency HIV Study. Clin Infect Dis 2007; 44:287–294.
4. Bhaskaran K, Hamouda O, Sannes M, Boufassa F, Johnson AM, Lambert PC, Porter K. Changes in the risk of death after HIV seroconversion compared with mortality in the general population. JAMA 2008; 300:51–59.
5. Welch KJ, Morse A. Survival patterns among HIV + individuals based on healthcare utilization. J Natl Med Assoc 2001; 93:214–219.
6. Losina E, Schackman BR, Sadownik SN, Gebo KA, Walensky RP, Choisier JJ, et al. Racial and sex disparities in life expectancy losses among HIV-infected persons in the United States: impact of risk behavior, late initiation, and early discontinuation of antiretroviral therapy. Clin Infect Dis 2009; 49:1570–1578.
7. Lemly DC, Shepherd BE, Hulgan T, Rebeiro P, Stinnette S, Blackwell RB, et al. Race and sex differences in antiretroviral therapy use and mortality among HIV-infected persons in care. J Infect Dis 2009; 199:991–998.
8. Mugaizzo MJ, Lin HY, Allison JJ, Giordano TP, Willig JH, Raper JL, et al. Racial disparities in HIV virologic failure among individuals with access to care. J Acquir Immune Defic Syndr 2009; 50:100–108.
9. Silverberg MJ, Leyden W, Quesenberry CP Jr, Horberg MA. Race/ethnicity and risk of AIDS and death among HIV-infected patients with access to care. J Gen Intern Med 2009; 24:1065–1072.
10. Weintrob AC, Grandits GA, Agan BK, Ganesan A, Landrum ML, Crum-Cianflone NF, et al. Virologic response differences between African Americans and European Americans initiating highly active antiretroviral therapy with equal access to care. J Acquir Immune Defic Syndr 2009; 52:574–580.
11. Mugaizzo MJ, Lin HY, Willig JH, Westfall AO, Ulett KB, Routman JS, et al. Missed visits and mortality among patients establishing initial outpatient HIV treatment. Clin Infect Dis 2009; 48:248–256.
12. Buchacz K, Baker RK, Moorman AC, Richardson JT, Wood KC, Holmberg SD, Brooks JT. Rates of hospitalizations and associated diagnoses in a large multisite cohort of HIV patients in the United States, 1994–2005. AIDS 2008; 22:1345–1354.
13. Crum NF, Riffenburgh RH, Wegner S, Agan BK, Tasker SA, Spooner KM, et al. Comparisons of causes of death and mortality rates among HIV-infected persons: analysis of the pre, early, and late HAART (highly active antiretroviral therapy) eras. J Acquir Immune Defic Syndr 2006; 41:194–200.
14. Sabin CA, Smith CJ, Youle M, Lampe FC, Bell DR, Puradireja DJ, et al. Deaths in the era of HAART: contribution of late presentation, treatment exposure, resistance and abnormal laboratory markers. AIDS 2006; 20:67–71.
15. Marin B, Thiebaut R, Bucher HC, Rondeau V, Costagliola D, Donnici M, et al. Non-AIDS-defining deaths and immunodeficiency in the era of combination antiretroviral therapy. AIDS 2009; 23:1743–1753.
16. Neuhaus J, Angus B, Kowalska JD, La Rosa A, Sampson J, Wentworth D, Micciche A. Risk of all-cause mortality associated with nonfatal AIDS and serious non-AIDS events among adults infected with HIV. AIDS 2010; 24:697–706.
17. Justice AC. Prioritizing primary care in HIV: comorbidity, toxicity, and demography. Top HIV Med 2006; 14:159–163.
18. Centers for Disease Control and Prevention (CDC). Electronic record linkage to identify deaths among persons with AIDS – District of Columbia, 2000-2005. MMWR Morb Mortal Wkly Rep 2008; 57:631–634.
19. Hooshary D, Hanson DL, Wolfe M, Selik RM, Buskin SE, McNaughten AD. Trends in perimortal conditions and mortality rates among HIV-infected patients. AIDS 2007; 21:2093–2100.
20. Lau B, Gange SJ, Moore RD. Risk of non-AIDS-related mortality may exceed risk of AIDS-related mortality among individuals enrolling into care with CD4+ counts greater than 200 cells/mm3. J Acquir Immune Defic Syndr 2007; 44:179–187.