The Influence of Sex, Race/Ethnicity, and Educational Attainment on Human Immunodeficiency Virus Death Rates Among Adults, 1993-2007

Edgar P. Simard, PhD, MPH; Mesfin Fransua, MD; Deepa Naishadham, MA, MS; Ahmedin Jemal, DVM, PhD

Background: Overall declines in human immunodeficiency virus (HIV) mortality may mask patterns for subgroups, and prior studies of disparities in mortality have used area-level vs individual-level socioeconomic status measures. The aim of this study was to examine temporal trends in HIV mortality by sex, race/ethnicity, and individual level of education (as a proxy for socioeconomic status).

Methods: We examined HIV deaths among non-Hispanic white, non-Hispanic black, and Hispanic men and women aged 25 to 64 years in 26 states (1993-2007; N=91,307) reported to the National Vital Statistics System. The main outcome measures were age-standardized HIV death rates, rate differences, and rate ratios by educational attainment and between the least- and the most-educated (≤12 vs ≥16 years) individuals.

Results: Between 1993-1995 and 2005-2007, mortality declined for most men and women by race/ethnicity and educational levels, with the greatest absolute decreases for nonwhites owing to their higher baseline rates. Among men with the most education, rates per 100,000 population decreased from 117.89 (95% CI, 101.08-134.70) to 15.35 (12.08-18.62) in blacks vs from 26.42 (24.93-27.92) to 1.79 (1.50-2.08) in whites. Rates were unchanged for the least-educated black women (26.76; 95% CI, 24.30-29.23; during 2005-2007) and remained high for similarly educated black men (52.71; 48.96-56.45). Relative declines were greater with increasing levels of education (P < .001), resulting in widening disparities. Among men, the disparity rate ratio (comparing the least and the most educated) increased from 1.04 (95% CI, 0.89-1.21) during 1993-1995 to 3.43 (2.74-4.30) during 2005-2007 for blacks and from 0.98 (0.91-1.05) to 2.82 (2.34-3.40) for whites.

Conclusion: Although absolute declines in HIV mortality were greatest for nonwhites, rates remain high among blacks, especially in the lowest educated groups, underscoring the need for additional interventions.


Widespread use of highly active antiretroviral therapy (HAART), available since 1996 for the treatment of human immunodeficiency virus (HIV) infection, has resulted in steep declines in HIV-related mortality through partial immune reconstitution, thereby preventing highly fatal opportunistic infections and other sequelae. Although HAART use is associated with prolonged survival from HIV infection and increased time to AIDS onset, not all groups have benefitted equally from its availability. Most striking are disparate patterns of HIV mortality in the United States: HIV has risen in prominence as a cause of death for blacks while simultaneously falling in prominence for whites, and it was the ninth leading cause of death among blacks vs the 24th leading cause of death among whites in 2007.

Many factors influence racial and ethnic disparities in HIV mortality rates, including differentials in the prevalence of HIV infection, delays in diagnosis, and an extended period before HAART initiation. Despite the lack of a clear understanding of many of these factors, current evidence suggests that blacks have an elevated risk of death from HIV. Low socioeconomic status (SES) also has been associated with elevated HIV mortality, although previous studies either did not stratify by race/ethnicity or evaluated racial differences in mortality only for men.

See Invited Commentary at end of article
Furthermore, these studies used county-level measures of SES, which may not accurately reflect the influence of individual-level SES on HIV death rates. Individual-level SES is likely to represent an individual’s access to the health care system because, even within small areas, there are large gradations in resource distribution. A previous study examined major causes of death in the United States (including HIV) by SES, although it ended in 2001 and did not focus on HIV. Herein, we examine trends in HIV mortality by individual levels of educational attainment (as a proxy for SES) and by sex and race/ethnicity for the major segments of the population affected by the HIV epidemic.

DATA SOURCES

We obtained HIV mortality data (1993-2007) from the National Vital Statistics System administered by the National Center for Health Statistics for non-Hispanic white, non-Hispanic black, and Hispanic men and women, the largest demographic groups with information available during the HIV epidemic. Deaths due to HIV infection (ie, HIV infection was the underlying cause of death) were classified according to the coding rules of the International Classification of Diseases, Ninth Revision (ICD-9; codes 042-044) for deaths occurring during 1993-1998 and according to the ICD-10 (codes B20-24) for deaths occurring from 1999 onward. Although many HIV-infected individuals who die have multiple serious medical conditions at the time of their death, HIV infection was ultimately selected as the condition that initiated the train of events leading directly to death by interpreting the multiple causes of death on death certificates. The study was exempted from human subjects review because it used publicly available deidentified vital statistics data.

Educational attainment recorded on death certificates was considered a marker of SES because education is associated with health, wealth, and access to the health care system. Educational attainment based on years of schooling completed as reported by next of kin was classified into 3 categories: 12 years or fewer (high school graduate or less), 13 to 15 years (some college education), and 16 years or more (college graduate or postgraduate) and is the only individual-level SES marker on the absolute scale, weighted by the inverse of their variance) by education attainment strata. Rates were suppressed if they were based on fewer than 10 deaths, in accordance with National Center for Health Statistics data use guidelines. If educational attainment was missing, those observations were excluded from education-specific analyses. We sought to describe absolute and relative trends in declining HIV death rates by sex, race/ethnicity, and educational attainment. On the absolute scale, we calculated rate differences with corresponding 95% CIs as the difference between rates during 2005-2007 (reflecting mortality during widespread HAART use) and 1993-1995 (when rates were at their peak and before widespread HAART use) by sex, race/ethnicity, and educational attainment. We also calculated rate differences for those with 12 or fewer vs 16 or more years of education to assess education disparities across the 2 calendar periods, and rate differences were considered significant if their 95% CIs excluded the null value of zero. The same comparisons were conducted on the relative scale by calculating rate ratios (RRs) with corresponding 95% CIs, and RRs were considered significant if their 95% CIs excluded the null value of one. We also tested for a monotonic trend in RRs (on the log scale, weighted by the inverse of their variance) by education categories using linear regression. The trend was considered significant if the Wald χ² test for that parameter had a P value less than .05. We also evaluated sex- and educational attainment–specific death rates between non-Hispanic whites and non-Hispanic blacks by calendar period to assess absolute and relative changes in rates over time by educational levels; these outcomes were considered significantly different if their respective 95% CIs did not overlap. Analyses were conducted using SAS, version 9.3 (SAS Institute, Inc).

Three-year mortality rates with corresponding 95% CIs during 1993-2007 by sex and educational attainment are presented for non-Hispanic whites and non-Hispanic blacks because these groups accounted for most deaths during the study. Three-year rates were calculated for stability and because these categories allow for the comparison of rates during 1993-1995, reflecting mortality during the monotherapy and/or dual-HIV therapy era, whereas those occurring during 1996 onward reflect mortality in the HAART era.

RESULTS

Our analysis included 91,307 deaths due to HIV during 1993-2007 among people aged 25 to 64 years in 26
states. Generally, the proportion of all deaths among non-Hispanic whites decreased over time, while the proportion of deaths among non-Hispanic blacks increased, with less striking changes for Hispanics (Table 1). Within each race/ethnicity, most deaths occurred among those with low levels of educational attainment (ie, ≤12 years), and this proportion generally increased over time.

Overall, death rates due to HIV infection declined over time for most men and women for each race/ethnicity and educational level (Figure 1). The largest absolute declines in death rates between 1993-1995 and 2005-2007 were among non-Hispanic blacks and Hispanics of every educational level due to their high baseline death rates relative to non-Hispanic whites (Figure 1 and Table 2). For example, the largest absolute decline was for the most educated (ie, ≥16 years of education) non-Hispanic black men (rate difference, 102.54; 95% CI, 85.42-119.66), although there were significant declines for men and women of every racial/ethnic and educational group except for the least-educated non-Hispanic black women and for Hispanic women with 13 to 15 years of education (Table 2).

Overall, HIV mortality rates also significantly declined on the relative scale for men and women of every race/ethnicity (Table 2). Relative declines were largest for those with the highest level of educational attainment (ie, ≥16 years): 93% (RR, 0.07; 95% CI, 0.06-0.08) for non-Hispanic white men and 88% (0.12; 0.06-0.25) for non-Hispanic white women. Death rates also significantly declined for most non-Hispanic black men and women, although the relative declines were generally smaller than those observed for non-Hispanic whites, and rates were unchanged for non-Hispanic black women with 12 or fewer years of education (RR, 0.90; 95% CI, 0.79-1.02). Relative declines in death rates among Hispanic men were steepest for those with 16 or more years of education (RR, 0.06; 95% CI, 0.03-0.14). Notably, the magnitude of the relative declines (as measured by the RR) increased with increasing levels of educational attainment for non-Hispanic white and non-Hispanic black men and women and for Hispanic men (P < .001 for all groups).

Between 1993-1995 and 2005-2007, both absolute and relative disparities in HIV death rates significantly widened between the most- and least-educated non-Hispanic white and non-Hispanic black men (Table 2). Among non-Hispanic white women, the relative education disparity significantly widened from an RR of 3.68 (95% CI, 2.63-5.17) during 1993-1995 to 17.80 (9.13-34.69) during 2005-2007, and there were no significant changes in the education disparities for other women.

Death rates due to HIV infection were also significantly elevated among non-Hispanic blacks relative to non-Hispanic whites within every education category. For example, among the most-educated men, rates were 4 times higher (95% CI, 3.83-5.20) during 1993-1995 and almost 9 times higher (6.56-11.21) during 2005-2007 among blacks compared with whites (Figure 2). Death rates were also significantly higher for non-Hispanic black vs non-Hispanic white women by all levels of educational attainment (Figure 2). Notably, among non-Hispanic black men with the highest levels of education (ie, ≥16 years) during 2005-2007, rates were more than 3 times as high compared with those among the least-educated (ie, ≤12 years) non-Hispanic white men (15.35 vs 5.04 per 100 000 population) (Table 2).
In this large population-based analysis of trends in HIV death rates, we document overall significant, yet different, absolute and relative declines in mortality by sex, race/ethnicity, and individual-level educational attainment as a proxy for SES. There were strong declines for all groups except for non-Hispanic black women of low SES. Relative declines were generally greater for those with higher educational attainment and for non-Hispanic whites, and these trends resulted in widening gaps between these groups. However, absolute declines were generally greater among nonwhites owing to their higher baseline rates. To our knowledge, this is the first study to assess declines in HIV mortality both within and between sex and racial and ethnic groups using detailed individual-level SES information. We identify several groups for whom rates remained unchanged and/or with a substantial burden of HIV mortality, even during the HAART era.

Our findings complement those of others demonstrating heterogeneity both in magnitudes of decline and in death rates themselves by sex and race/ethnicity and provide additional context by individual levels of educational attainment as a proxy for SES. Relative declines in...
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ty, but HIV death rates were nonetheless alarmingly high for these men vs non-Hispanic whites and Hispanics during 2005-2007. Notably, HIV death rates among non-Hispanic black men with 12 or fewer years of education (52.71 per 100 000 population in 2005-2007) were higher than rates among similarly educated non-


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<td>RD (95% CI)</td>
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<td>≤12</td>
<td>1.72 (1.67 to 1.77)</td>
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<td>13-15</td>
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<td>≥16</td>
<td>0.77 (0.75 to 0.79)</td>
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<td>RD (95% CI) for ≤12 vs ≥16 y</td>
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<td>RR (95% CI) for ≤12 vs ≥16 y</td>
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<td>Non-Hispanic black, y</td>
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<td>All education</td>
<td>22.50 (20.75 to 24.24)</td>
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<td>≤12</td>
<td>21.99 (20.50 to 23.58)</td>
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<td>11.24 (10.00 to 12.58)</td>
<td>7.50 (6.32 to 8.72)</td>
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<td>RD (95% CI) for ≤12 vs ≥16 y</td>
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<td>RR (95% CI) for ≤12 vs ≥16 y</td>
<td>0.71 (0.70 to 0.72)</td>
<td>0.49 (0.48 to 0.50)</td>
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Abbreviations: ellipses, rate was suppressed owing to small cell counts; HIV, human immunodeficiency virus; NA, not available; RD, rate difference; RR, rate ratio.

aDeath rates per 100 000 persons in the general population were calculated by dividing the number of people with HIV recorded as the underlying cause of death on their death certificate by the corresponding estimated population by sex, race/ethnicity, and educational attainment and were age adjusted to the 2000 standard US population. The “All education” category includes individuals with unspecified levels of educational attainment.

bRD is calculated as the difference in rates between 2005-2007 and 1993-1995.


dP < .001, assessed via linear regression.

In addition, the black-to-white mortality disparities were generally similar across educational levels in both periods (1993-1995 and 2005-2007), highlighting racial disparities in HIV prevalence, treatment,
and prevention within each level of education, which may be due to a combination of societal and environmental factors. Nonetheless, our findings suggest the importance of considering individuals not only on the basis of race/ethnicity but also by SES for the purposes of allocating resources for HIV prevention and treatment.

Among women, nonwhites had smaller relative but greater absolute declines in HIV mortality. Notably, there was no significant change in death rates for non-Hispanic black women with 12 or fewer years of education on either scale. Death rates also declined for some Hispanic women but remained elevated compared with those among non-Hispanic whites in every education category during 2005-2007. On the basis of these findings, we posit that non-Hispanic black men and minority women (ie, non-Hispanic blacks and Hispanics), and in particular those with low SES, may be exceptionally vulnerable to HIV deaths owing to a combined lack of knowledge of HIV prevention, lack of knowledge of their own HIV status, lack of access to the health care system, social stigma, and marginalization.14,32

Figure 2. Trends in disparities in human immunodeficiency virus infection death rates between non-Hispanic blacks and non-Hispanic whites by sex, educational attainment, and calendar period in 26 states, 1993-2007. Error bars represent 95% CIs. Analyses were restricted to individuals with a specified level of education recorded on death certificates.
Higher HIV mortality among non-Hispanic blacks vs non-Hispanic whites may be at least in part explained by a number of complex factors, including differential rates of HIV infection by sex, race/ethnicity, and SES, as well as delays in diagnosis, lack of receipt of HAART, poor adherence to HAART, and prevalence of comorbid conditions (eg, tuberculosis). Increased access to the healthcare system may be particularly important. A study in a managed care organization found no racial disparities in mortality, underscoring the potential role of access to care in ameliorating disparities in other settings. Higher rates of all-cause mortality among HIV-infected individuals receiving treatment through publicly funded sources (eg, low SES) vs privately insured individuals were recently found in another study, although differences in mortality largely reflected variations in comorbidities between the two groups. A recent meta-analysis of data from the AIDS Clinical Trials Group suggested that black race was associated with a 40% increased risk for virologic failure after adjustment for factors associated with HAART adherence, underscoring the need for additional research assessing the roles of both societal-level and host characteristics in optimizing HAART regimens. Finally, interventions that improve clinical management of HIV infections among individuals with low SES, earlier initiation of HAART, and linkage to care are also important to improving both individual- and community-level HIV-related outcomes.

Our study has a number of strengths. First, the large, population-based nature of our data allows for the accurate estimation of HIV death rates by individual-level SES among non-Hispanic whites and non-Hispanic blacks, the two largest groups affected by the HIV epidemic in the United States. In addition, data on educational attainment was 96% complete. We also adjusted for the potential impact of changes in coding practices for HIV-related deaths between ICD-9 and ICD-10, allowing for an accurate assessment of temporal trends in rates. Also, we present findings on both the absolute and relative scales, providing additional context with which to consider the burden of HIV-related deaths in these populations, especially among non-Hispanic blacks, who are disproportionately affected by HIV and among whom most new infections now occur.

Our study also has limitations. We took individual levels of educational attainment to be a marker for SES, although SES is a multidimensional construct comprised of individual-level and societal-level factors. We were unable to account for other factors associated with HIV mortality, including clinical characteristics (eg, nadir CD4 or response and adherence to HAART) as well as other determinants, such as health insurance, because this information is not collected on death certificates. In addition, consistent educational attainment information was available from only 26 states during 1993-2007, precluding the generalization of our findings to other states and to those not aged 25 to 64 years. However, the relative declines in the 26 states in the study were similar to those in the remaining 24 states and the District of Columbia for people of the same ages. Death rates from HIV infection were higher in the areas not included in the current analysis, reflecting geographic features of the HIV epidemic, resulting in different absolute changes over time. Nonetheless, the conclusions drawn from absolute and relative changes were the same. Finally, we did not examine specific contributing causes of death, of which there are likely to be many among people with HIV (eg, opportunistic infections, malignant neoplasms, or cardiovascular disease), and evaluating trends in mortality from these sequelae may also be informative and should be an area of future research. Despite these limitations, our findings suggest the aggregate effect of changing patterns of access to HIV prevention, screening, and treatment by SES levels on progress in declining HIV death rates over time in the United States.

We documented substantial absolute declines in HIV death rates during 1993-2007 for all groups, although relative declines were greatest among those with the highest vs lowest levels of SES, leading to widening inequalities. Notably, HIV death rates remained markedly high among non-Hispanic black men of all SES levels and were unchanged for non-Hispanic black women in the lowest SES strata. These findings suggest the need for focused interventions and resources to facilitate the identification of high-risk individuals, as well as entry and retention into care for these most vulnerable groups affected by the HIV epidemic in the United States.
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REFERENCES


