Educational attainment and all-cause and HIV mortality among adults — United States, 2018–2021

Nelson Adekoya, DrPH[1*] and Man-Huei Chang, MPH[1]

[1]National Center for HIV, Viral Hepatitis, STD, and TB Prevention, Centers for Disease Control and Prevention, Atlanta, Georgia, USA.

Abstract

Objective: We described age-adjusted death rates of all-cause and HIV and educational attainment among US adult residents at national and state levels during 2018–2021.

Method: We used 2018–2021 mortality data from the Centers for Disease Control and Prevention underlying cause-of-death files and the American Community Survey (2017–2021) to assess the influence of educational attainment on all-cause deaths and HIV deaths. We conducted unadjusted regression and Pearson's correlation to test for the association between age-adjusted death rates for all-cause and HIV mortality and educational attainment.

Results: Among 35 states that recorded educational attainment above the national average of 88.9%, age-adjusted mortality rates were lower for 22 states, compared with the nationwide all-cause mortality rate. Similar patterns of increased HIV age-adjusted mortality rates were observed with decreased educational attainment. A significant correlation was identified between increased mortality rates for all-cause deaths (r = –0.45; *P* <.0021) and HIV deaths (r = –0.66; *P* <.0001) and decreased educational attainment. Black population had the highest all-cause and HIV mortality rate than among White and Hispanic/Latino population. However, the lowest educational attainment rates were observed among Hispanic/Latino populations (71.2%) than Black population (87.2%) and White (93.5%) population during 2017–2021.

Conclusion: This ecological study shows the importance of reducing disparities in education to improve health.

Keywords: HIV; sex; mortality; all-cause; educational attainment

Introduction:

Several risk factors (e.g., smoking, diet, lack of exercise, use of seatbelts) leading to premature death have been addressed in the United States, resulting in notable declines in mortality rates and increased life expectancy (i.e., the expected number of years that a group of persons might live at each attained age if the group is subject to the age-specific death rates prevailing for the actual population in a given year) (*1,2*). One socioeconomic factor affecting health outcome determination is education, whereby an increase in educational achievement decreases income inequality and improves health outcomes *(3)*. At least one study has shown that cumulative mortality decreases drastically as educational achievement increases, and individuals who lack primary or secondary education have higher risk for death than those with tertiary education *(4)*. Similarly, the relationship between educational levels and all-cause mortality among persons with HIV has been documented *(5,6)*. Because education is a well-established social determinant of health, and there is a documented negative linear relationship between educational level and HIV infection rate *(7),* it is essential to continually assess educational levels and HIV

mortality to identify, develop, and implement additional prevention strategies *(8)*.

Education enhances citizens' ability to process behavioral development which is necessary to build healthy community. Education is associated with employment, income, health insurance, and health care utilization which are associated with better health outcomes and lower death rates *(9)*. Recognizing the role of education in community health, *Healthy People 2020 (10)* and *Healthy People 2030 (11)* specifically placed education among its leading health indicators. Additionally, the National HIV/AIDS Strategy for United States developed by the White House Office of National AIDS Policy, in collaboration with federal and community partners, unambiguously stressed that education is an important socioeconomic factor that should be considered in approaches to address individual, community, and structural factors and inequalities that contribute to HIV transmission *(12)*.

Education is sensitive to structural factors such as economy which is important in healthcare delivery system *(13)*. Nationwide, educational attainment has improved; however, mortality rate inequalities exist between states *(8,12)*. While education can be used as an instrument to understand HIV mortality differentials in communities (population health), state-level information is sparse *(14)*. The National HIV Surveillance Report presents HIV deaths by age, race, sex, transmission category, and region of residence but does not include educational attainment and deaths by state *(15)*. Because HIV infections are higher among younger persons and inequalities in mortality are more pronounced among this population *(16)*, we present an ecological study which combines state-specific all-cause mortality and HIV mortality data from the National Centers for Health Statistics Vital Statistics with state-specific data on educational attainment from the American Community Survey (ACS). Given that education has a protective effect on most causes of death *(5,6)*, we present the overall correlation between educational attainment and all-cause mortality and HIV mortality to determine whether both follow similar patterns.

Methods

National Vital Statistics System data were obtained from WONDER, which provides customized reports based on state-reported death certificate records *(17)*. The underlying cause of death data on all-cause mortality and HIV deaths during 2018–2021 were analyzed. Mortality and educational attainment analyses were limited to persons aged ≥25 years *(18)*, in parallel with the ACS on educational attainment. Population estimates from the U.S. Census Bureau were used to calculate death rates, and rates were age-adjusted to the 2000 standard U.S. population. Results are presented for all-cause deaths and HIV mortality at the national and state levels. Because access to care can affect

health problems regardless of educational attainment, especially in rural states *(19)*, all-cause mortality death was used as a mean test (standard) because composite risk factors are inclusive (e.g., smoking, high blood pressure, lack of exercise, high cholesterol level, family history, and sedentary life), including heart diseases which is a major cause of death *(17)*. If the effect of education is substantial, the pattern noted for all-cause deaths would resemble HIV deaths. A previous study reported that cause-specific death rates indicate that changes in death rates for heart disease account for a substantial portion of the increase in educational differentials in overall mortality *(20)*. Death counts <10 was suppressed and deaths <20 are considered unreliable following the data source stipulations *(17)*.

Educational attainment statistics were obtained from ACS, an ongoing statistical survey conducted by the U.S. Census Bureau. Data are collected monthly on a random sample of the U.S. population regarding education, income, language proficiency, migration, and housing, among other characteristics. These monthly data are aggregated to generate annual estimates, which reflect the dynamics of U.S. population. The 2017–2021 ACS 5-year estimates were used to calculate national- and state-level percentages of persons aged ≥25 years with a high school or higher educational attainment; mortality rates for both all-cause and HIV mortality were compared with educational attainment. Educational attainment data by state were available for Non-Hispanic or Latino (Hispanic) White (NHW, herein referred to as White throughout the manuscript) and Hispanic or Latino persons but not for Non-Hispanic or Latino Black /African-American (Black) persons (although there is a table for Black /African-American persons).[1] We analyzed and presented data on sex. Lastly, we conducted unadjusted regression and Pearson's correlation to test for the association between age-adjusted death rates for all-cause and HIV mortality and educational attainment using SAS (version 9.4; SAS Institute). This analytic study did not involve human subjects research supervised by a CDC Institutional Review Board.

Results

All-Cause Deaths

During 2018–2021, a total of 12,288,169 deaths occurred in the United States among persons aged ≥25 years, for an age-adjusted mortality rate of 1,186.2 deaths/100,000 population (**Table 1**). Nationwide, Hawaii, California, and New York recorded the lowest overall mortality rates at 887.4, 1,008.4 and 1,041.1 deaths/100,000 population, respectively. Whereas Mississippi, West Virginia, and Alabama recorded the highest mortality rates at 1,577.9, 1,574.6, and 1,503.5 deaths/100,000 population, respectively. Although 18 states recorded mortality rates of <1,186.2 deaths/100,000 population, 13 states recorded rates >1,300 deaths/100,000 population, the majority of which

---

[1] Mortality & educational attainment data for the three major racial and ethnic groups (i.e., "NHW", "Black", and "Hispanic") as an Appendix. Data on educational attainment for race/ethnicity for Non-Hispanic Blacks aged >=25 are NOT available in ACS. Therefore, the mortality data along with the educational attainment

data in the Appendix was created for "Black or African American Alone" in which all ethnic origins (i.e., Hispanic, non-Hispanic, Latinos, or not stated) were included. Data on each racial and ethnic group were listed separately in each table by sex and in total. We only included this information as a supplemental material.

were in the South (Georgia, Alabama, Arkansas, Indiana, Kentucky, Louisiana, Mississippi, Missouri, Ohio, Oklahoma, South Carolina, Tennessee, and West Virginia). Four states recorded >1,500 deaths/100,000 population (Alabama, 1,503.5; Kentucky, 1,507.8; Mississippi, 1,577.9; and West Virginia, 1,574.6) and none of the southern states were represented in the first quartile of deaths (887.4–1,116.2 deaths/100,000 population).

TABLE 1. State-specific all-cause and HIV mortality, compared with educational attainment — United States, 2018-2021

State	All causes of death	Age-adjusted all-cause rate per 100,000	HIV deaths	Age adjusted HIV death rate per 100,000	High school graduate or higher (%)
Alabama	236,743.0	1,503.5	357.0	2.7	87.4
Alaska	19,577.0	1,152.2	12.0	Unreliable	93.3
Arizona	270,098.0	1,137.1	313.0	1.6	88.3
Arkansas	140,149.0	1,443.9	186.0	2.2	87.7
California	1,167,667.0	1,008.4	2,330.0	2.1	84.2
Colorado	168,704.0	1,070.0	177.0	1.1	92.4
Connecticut	133,243.0	1,053.0	190.0	1.6	91.1
Delaware	40,328.0	1,197.6	84.0	2.8	91.1
District of Columbia	21,331.0	1,179.3	250.0	13.9	92.2
Florida	897,825.0	1,076.7	2,670.0	4.2	89.0
Georgia	376,484.0	1,301.3	1,220.0	4.1	88.2
Hawaii	47,002.0	887.4	39.0	0.9	92.7
Idaho	61,937.0	1,168.8	18.0	Unreliable	91.2
Illinois	467,083.0	1,163.8	538.0	1.5	89.9
Indiana	281,642.0	1,360.8	271.0	1.5	89.8
Iowa	129,314.0	1,188.6	62.0	0.7	92.8
Kansas	116,696.0	1,253.0	86.0	1.0	91.6
Kentucky	209,744.0	1,507.8	183.0	1.5	87.7
Louisiana	200,761.0	1,445.2	523.0	4.2	86.2
Maine	62,014.0	1,202.5	35.0	0.8	93.7
Maryland	214,808.0	1,143.0	699.0	3.8	90.8
Massachusetts	246,020.0	1,064.0	226.0	1.0	91.2
Michigan	425,028.0	1,281.0	301.0	1.0	91.6
Minnesota	190,588.0	1,052.0	104.0	0.6	93.6
Mississippi	142,642.0	1,577.9	377.0	4.7	85.6
Missouri	267,372.0	1,324.9	251.0	1.5	91.0
Montana	44,169.0	1,201.7	14.0	Unreliable	94.4
Nebraska	70,833.0	1,154.6	51.0	1.0	91.7
Nevada	111,426.0	1,231.9	238.0	2.7	87.0
New Hampshire	52,711.0	1,108.8	26.0	0.6	93.6
New Jersey	326,099.0	1,096.1	664.0	2.3	90.5
New Mexico	85,539.0	1,280.3	93.0	1.5	86.8
New York	687,816.0	1,041.1	1,661.0	2.8	87.4
North Carolina	407,843.0	1,257.4	710.0	2.3	89.0
North Dakota	27,819.0	1,144.7	13.0	Unreliable	93.3
Ohio	529,200.0	1,365.6	437.0	1.3	91.1
Oklahoma	176,763.0	1,470.2	259.0	2.4	88.7
Oregon	156,329.0	1,127.7	153.0	1.2	91.5
Pennsylvania	570,299.0	1,230.9	465.0	1.1	91.4
Rhode Island	42,840.0	1,133.3	35.0	1.0	89.1
South Carolina	223,024.0	1,347.8	491.0	3.3	88.8
South Dakota	34,382.0	1,189.9	23.0	1.0	92.5
Tennessee	311,518.0	1,468.7	482.0	2.5	88.8
Texas	898,739.0	1,225.7	2,100.0	2.7	84.8
Utah	78,422.0	1,116.2	47.0	0.6	93.1
Vermont	25,005.0	1,103.5	16.0	Unreliable	93.9
Virginia	299,839.0	1,155.3	455.0	1.8	90.8
Washington	242,134.0	1,069.8	242.0	1.1	91.9
West Virginia	100,963.0	1,574.6	54.0	1.1	88.1
Wisconsin	227,418.0	1,170.6	109.0	0.7	92.9
Wyoming	22,239.0	1,231.3	Suppressed	Suppressed	93.7
Total	**12,288,169.0**	**1,186.2**	**Suppressed**	**Suppressed**	**88.9**

Mortality data source: Centers for Disease Control and Prevention, National Center for Health Statistics. National Vital Statistics System, Mortality 2018-2021 on CDC WONDER Online Database, released in 2021. Data are from the Multiple Cause of Death 2018-2021, as compiled from data provided by the 57 vital statistics jurisdictions through the Vital Statistics Cooperative Program. Accessed at http://wonder.cdc.gov/ucd-icd10-expanded.html on Jan 18, 2023 2:56:02 PM
Education attainment data source: U.S. Census Bureau, 2017-2021 American Community Survey 5-Year Estimates
Suppressed: death count less than 10 (more information: http://wonder.cdc.gov/wonder/help/ucd-expanded.html).
Unreliable: death count less than 20 (more information: http://wonder.cdc.gov/wonder/help/ucd-expanded.html).

The rate for men (1,407.9 deaths/100,000 population) was 41% higher than that for women (997.3/100,000 population), for an absolute rate difference of 411 (**Table 2**). Women in West Virginia (1,331.6), Mississippi (1,314.4), and Kentucky (1,276.2) had the highest mortality rates, compared with women in Hawaii (701.4), California (832.2), and Connecticut (879.0), who had the lowest mortality rates. Similarly, men in Mississippi (1,900.9), West Virginia (1,843.3), and Alabama (1,797.1) had the highest mortality rates, compared with the rates for men in Hawaii (1,098.5), California (1,213.2), and Minnesota (1,235.5).

TABLE 2. State-specific all-cause and HIV mortality, by sex, compared with educational attainment — United States, 2018-2021

	Male					Female				
State	All causes of death	Age-adjusted all-cause rate per 100,000	HIV deaths	Age adjusted HIV death rate per 100,000	High school graduate or higher (%)	All causes of death	Age-adjusted all-cause rate per 100,000	HIV deaths	Age adjusted HIV death rate per 100,000	High school graduate or higher (%)
Alabama	122635	1797.1	257	3.9	86.1	114108	1261	100	1.5	88.6
Alaska	11227	1336.4	Suppressed	Suppressed	92.8	8350	973.1	Suppressed	Suppressed	93.7
Arizona	146857	1341.8	263	2.7	87.6	123241	947.8	50	0.5	89.0
Arkansas	73156	1703.4	148	3.6	86.6	66993	1221.3	38	0.9	88.7
California	619087	1213.2	1996	3.6	83.8	548580	832.3	334	0.6	84.5
Colorado	89310	1252	157	2.0	91.9	79394	907.9	20	0.3	92.8
Connecticut	66568	1264.5	131	2.3	90.3	66675	879	59	1.1	91.8
Delaware	21142	1432.2	60	4.0	89.6	19186	998.1	24	1.7	92.4
District of Columbia	10975	1425.1	150	17.7	92.0	10356	981.5	100	10.7	92.5
Florida	476720	1281.6	1847	5.7	88.3	421105	894.5	823	2.7	89.8
Georgia	193669	1529.2	867	6.1	86.9	182815	1112.4	353	2.4	89.4
Hawaii	25149	1098.5	37	1.7	93.0	21853	701.4	Suppressed	Suppressed	92.4
Idaho	32706	1335	18	Unreliable	90.3	29231	1014.4	Suppressed	Suppressed	92.0
Illinois	238500	1394.9	425	2.4	89.2	228583	973.1	113	0.6	90.6
Indiana	144157	1611	223	2.4	89.1	137485	1153.3	48	0.5	90.4
Iowa	65603	1412.6	52	1.2	92.1	63711	1001.1	10	Unreliable	93.5
Kansas	59687	1476.1	71	1.7	90.8	57009	1064.1	15	Unreliable	92.4
Kentucky	108796	1780.9	153	2.5	86.4	100948	1276.2	30	0.5	88.9
Louisiana	105336	1731.8	357	5.8	84.4	95425	1203.9	166	2.6	87.9
Maine	32185	1434.1	27	1.2	92.6	29829	1002.1	Suppressed	Suppressed	94.7
Maryland	109467	1369.6	486	5.6	89.9	105341	958.8	213	2.2	91.6
Massachusetts	122730	1281.2	152	1.5	90.8	123290	891.2	74	0.7	91.5
Michigan	218368	1514.4	240	1.7	90.9	206660	1084.6	61	0.4	92.3
Minnesota	97304	1235.5	87	1.1	93.1	93284	896.1	17	Unreliable	94.0
Mississippi	74310	1900.9	259	6.7	83.5	68332	1314.4	118	2.9	87.5
Missouri	138301	1580.3	215	2.5	90.3	129071	1108.8	36	0.4	91.7
Montana	23914	1409.3	11	Unreliable	93.7	20255	1010.2	Suppressed	Suppressed	95.0
Nebraska	36035	1353.5	35	1.4	91.0	34798	984.6	16	Unreliable	92.4
Nevada	62415	1448.8	193	4.5	86.8	49011	1028.9	45	1.0	87.2
New Hampshire	27303	1312.2	19	Unreliable	92.7	25408	933.6	Suppressed	Suppressed	94.5
New Jersey	163602	1315.5	458	3.4	90.1	162497	917.2	206	1.4	90.9
New Mexico	46675	1541.3	81	2.7	85.9	38864	1044.5	12	Unreliable	87.6
New York	346252	1256.4	1155	4.0	87.0	341564	867.6	506	1.6	87.8
North Carolina	208992	1491.4	475	3.1	87.5	198851	1063.9	235	1.5	90.5
North Dakota	14641	1376.9	10	Unreliable	92.7	13178	943.3	Suppressed	Suppressed	93.9
Ohio	269351	1619.5	357	2.2	90.6	259849	1155.4	80	0.5	91.7
Oklahoma	92585	1731.1	213	4.1	87.8	84178	1245.5	46	0.8	89.6
Oregon	81675	1317.8	134	2.2	90.6	74654	960.7	19	Unreliable	92.4
Pennsylvania	287268	1474.8	336	1.7	90.8	283031	1030.6	129	0.7	91.9
Rhode Island	21005	1360.5	25	1.4	88.6	21835	951.9	10	Unreliable	89.5
South Carolina	116693	1601.1	334	4.7	87.4	106331	1132.9	157	2.0	90.0
South Dakota	18028	1425	16	Unreliable	91.8	16354	989.7	Suppressed	Suppressed	93.3
Tennessee	162056	1742.3	342	3.7	87.7	149462	1238.4	140	1.5	89.8
Texas	476994	1451	1654	4.3	84.1	421745	1032.3	446	1.2	85.5
Utah	40968	1252.6	44	1.1	92.6	37454	991.1	Suppressed	Suppressed	93.6
Vermont	12931	1304.3	14	Unreliable	92.3	12074	929	Suppressed	Suppressed	95.3
Virginia	153430	1356.1	336	2.7	90.1	146409	987.1	119	0.9	91.5
Washington	126363	1248.4	206	1.9	91.4	115771	914.1	36	0.3	92.5
West Virginia	52847	1843.3	37	1.4	86.9	48116	1331.6	17	Unreliable	89.1
Wisconsin	116764	1380.3	79	1.0	92.0	110654	991.6	30	0.4	93.8
Wyoming	11992	1427.7	Suppressed	Suppressed	93.3	10247	1046.8	Suppressed	Suppressed	94.2
Total	**6374724**	**1407.9**	**15256**	**3.3**	**88.1**	**5913445**	**997.3**	**5093**	**1.1**	**89.6**

Mortality data source: Centers for Disease Control and Prevention, National Center for Health Statistics. National Vital Statistics System, Mortality 2018-2021 on CDC WONDER Online Database, released in 2021. Data are from the Multiple Cause of Death Files, 2018-2021, as compiled from data provided by the 57 vital statistics jurisdictions through the Vital Statistics Cooperative Program. Accessed at http://wonder.cdc.gov/ucd-icd10-expanded.html on Jan 18, 2023 2:56:02 PM
Education attainment data source: U.S. Census Bureau, 2017-2021 American Community Survey 5-Year Estimates
Suppressed: death count less than 10 (more information: http://wonder.cdc.gov/wonder/help/ucd-expanded.html).
Unreliable: death count less than 20 (more information: http://wonder.cdc.gov/wonder/help/ucd-expanded.html).

HIV Deaths

Minnesota, New Hampshire, and Utah recorded the lowest overall HIV mortality rates, each with 0.6 deaths/100,000 population. Alternatively, District of Columbia, Mississippi, Florida, and Louisiana recorded the highest mortality rates at 13.9, 4.7, 4.2, and 4.2 deaths/100,000 population, respectively. Although 13 states recorded mortality rates of ≤1 death/100,000 population, 12 states recorded rates of ≥2.7 deaths/100,000 population; there was no noteworthy concentration of states by region, unlike all-cause deaths recorded in the South (Georgia, Alabama, Delaware, District of Columbia, Florida, Maryland, Nevada, New York, Louisiana, Mississippi, South Carolina, and Texas). The District of Columbia (13.9) recorded the highest rate compared with other states; 4 states that recorded ≥4.1deaths/100,000 population were in the South (Georgia, Florida, Louisiana, and Mississippi). None of the southern states were represented in the first quartile of deaths (0.9–1.0 death/100,000). Wyoming did not meet the reporting threshold (death counts <10), and rates were unreliable (death count < 20) for 6 states (Alaska, Idaho, Montana, North Dakota, Vermont, and Wyoming).

The HIV mortality rate for men (3.3 deaths/100,000 population) was 3 times higher than that for women (1.1/100,000 population), with an absolute rate difference of 2.2 (Table 2). Women in the District of Columbia (10.7), Mississippi (2.9), Florida (2.7), Louisiana (2.6), Georgia (2.4), and Maryland (2.2) had the highest mortality rates, compared with women in Washington (0.3), Wisconsin (0.4), and Colorado (0.3), who had the lowest mortality rates. Similarly, men in the District of Columbia (17.7), Mississippi (6.7), Louisiana (5.8), and Maryland

(5.6) had the highest mortality rates, compared with the rates for men in Wisconsin (1.0), Minnesota (1.1), and Utah (1.1). More small data points were suppressed or unreliable for females than males.

Educational Attainment, All-Cause Deaths, and HIV Deaths
Figure 1 presents the all-cause mortality rates, by state, from the lowest to the highest all-cause mortality rates. Beginning with the state ranked 31st (Texas, 1,225.7 deaths/100,000 population), there was a noteworthy gradient increase in mortality rates. The increase in mortality corresponded to a continuous decline in educational achievement, reaching 85.6% for Mississippi. Educational attainment
(high school completion or higher) ranged from 94.4% in Montana to 84.2% in California. California (84.2%), Texas (84.8%), and Mississippi (85.6%) had the lowest educational attainment. The relationship between HIV deaths and educational attainment was similar to that observed in all-cause deaths, where lower educational attainment corresponded with increased HIV death rates (**Figure 2**). Minnesota, New Hampshire, Utah, and Iowa, each with higher educational attainment, had lower HIV death rates. In contrast, Mississippi, Louisiana, Texas, and California, all with lower educational attainment, had higher HIV death rates. In 6 states, the educational attainment gradient was so high that adjusted death rates were too unreliable to report, suggesting an inverse relationship between educational attainment (Alaska, 93.3%; Idaho, 91.2%; Montana, 94.4%; North Dakota, 93.3%; Vermont, 93.9%; and Wyoming, 93.7%) and HIV deaths. A significant correlation was identified between increased mortality rates for all-cause deaths (r = –0.45; P <.0021) and HIV deaths (r = –0.66; P <.0001) and decreased educational attainment.

FIGURE 1. Statewide educational attainments and all-cause age-adjusted mortality rates — United States, 2018-2021
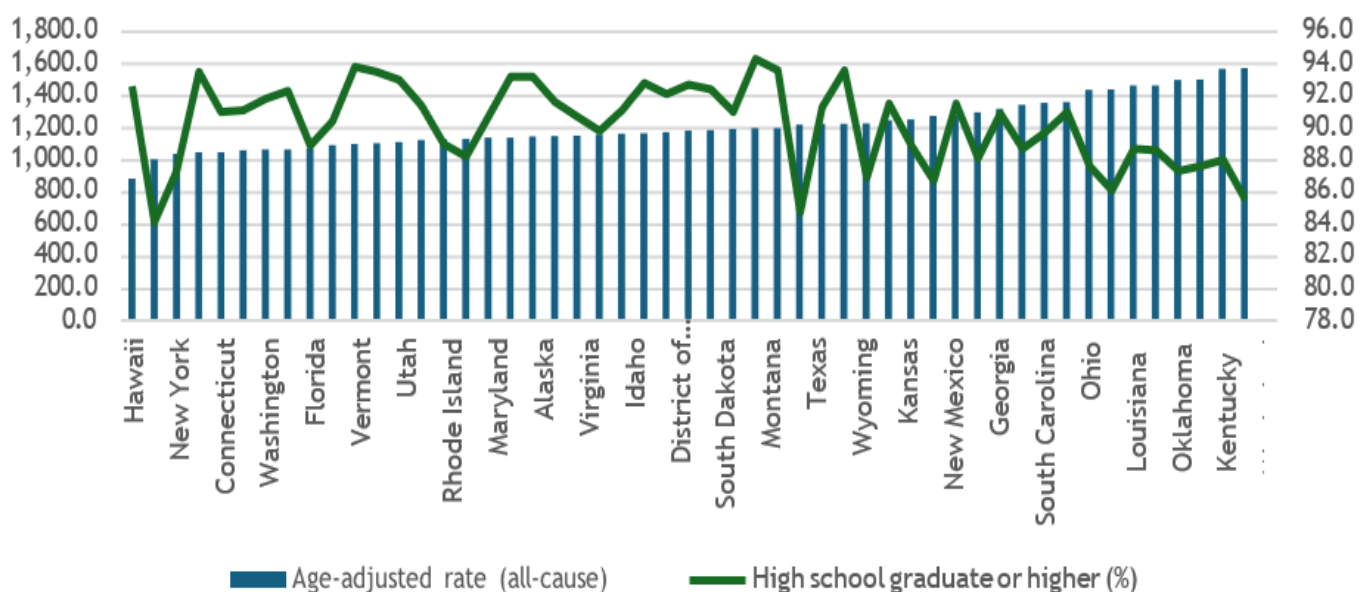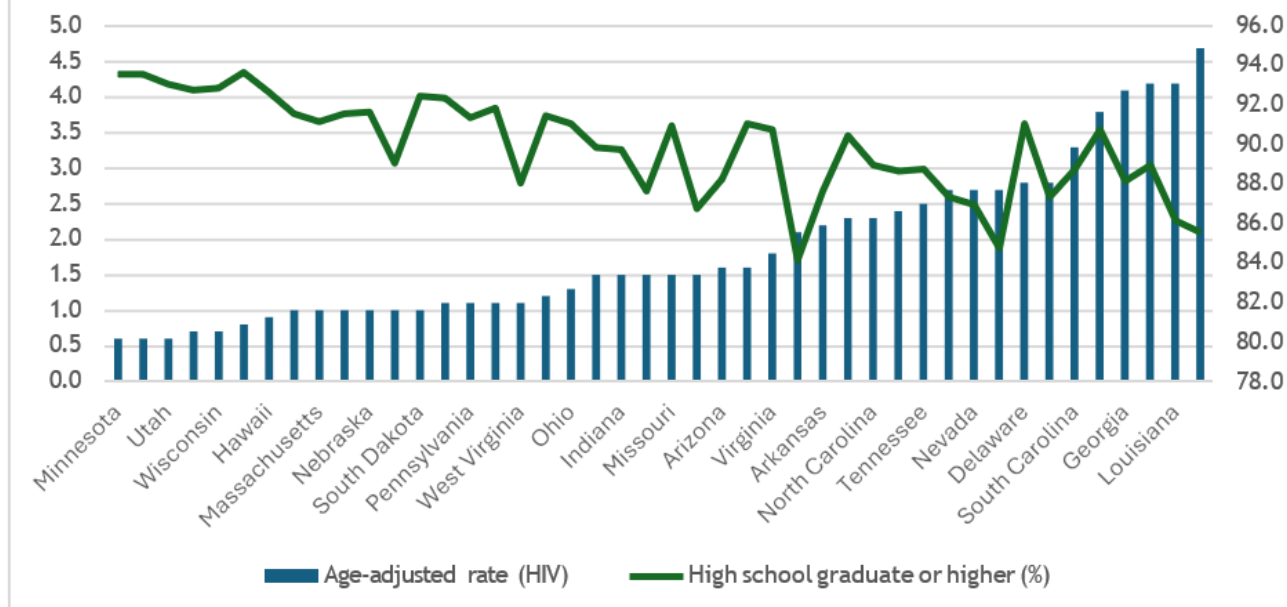
Legend: Age-adjusted rate (all-cause) | High school graduate or higher (%)

FIGURE 2. Statewide educational attainment and age-adjusted HIV mortality rates — United States*, 2018-2021

Race/ethnicity, Sex, Educational Attainment, All-Cause Deaths, and HIV Deaths

The state-specific all-cause and HIV deaths compared with educational attainment by sex and race/ethnicity (data not shown). Data on HIV age-adjusted death rates for race/ethnicity and sex were sparse and therefore were either suppressed or unreliable in certain states, making correlation test results unreliable. White population had the highest average educational attainment at 93.5% and only handful states recorded <90% educational attainment (Alabama, Kentucky, Louisiana, Mississippi, and West Virginia) among this population. The highest HIV age-adjusted death rates were recorded in Florida (2.1), Nevada (2.2), and Oklahoma (2.0) among non-Hispanic White persons. Fifteen states recorded HIV age-adjusted death rates greater than the national average for White population. Age-adjusted death rate was 4.5 times higher in males (1.8) in comparison to females (0.4). Age-adjusted all-cause death rate recorded for White population (1,213.8) is lower than for the Black population (1,448.5) but higher than the Hispanic/Latino population (941.2).

For Black population, the average age-adjusted HIV death rate was 8.8 deaths/100,000 with marked differences between males and females' Black population (12.7 versus 5.4). Thirteen states recorded age-adjusted death rates greater than the average for Black population (Delaware, 9.5; District of Columbia, 26.2; Florida, 15.9; Georgia, 10.2; Louisiana, 10.4; Maryland, 10.3; Mississippi, 10.3; Nevada, 9.0, New Jersey, 10.3; New York, 9.2; South Carolina, 9.7; Tennessee, 9.6; and Texas, 8.9). The average educational attainment of Black population is 87.2%. HIV age-adjusted death rate among Black males (12.7) was 2.35 times the rates among females' Black population (5.4). All-cause mortality age-adjusted rate of males (1,789.1) was much higher than the females in Black population (1,191.8).

For Hispanic/Latino population, the average educational

attainment was 71.2% which was substantially lower than the rate in Black population (87.2%) and White population (93.5%). Hispanic/Latino males recorded the lowest educational attainment at 69.7%. The average age-adjusted HIV death rate for Hispanic/Latino population group is 2.1 and rates were higher than the Hispanic/Latino population average among 7 states (Connecticut, 3.6; Florida, 2.4; Massachusetts, 2.8; New Jersey, 2.6; New York, 4.4; Oklahoma, 2.4; and Pennsylvania, 2.6). Hispanic/Latino population recorded the lowest all-cause mortality rate (941.2) in comparison to Black and White population groups. Similarly, age adjusted rates were lower for Hispanic/Latino males (1,151.1) and females (762.3) in comparison to White and Black population of these groups.

Discussion

This study examined the association of education on all-cause and HIV mortality among adults in the United States during 2018–2021. Among 35 states (69%) that recorded educational attainment (i.e., high school graduate or equivalent) above the national average of 88.9%, age-adjusted all-cause mortality rates were lower for 22 states (22/35; 63%), compared with the nationwide all-cause mortality rate. With the exception of California, New York, and Arizona, among the 16 states with the lowest educational attainment, age-adjusted mortality rates increased and were worse than the national average (13/16; 81%). Additionally, similar inverse patterns of increased adjusted mortality rates were identified when educational attainment and HIV deaths were examined. Because persons who are educated live longer and suffer less morbidity during their lifetime *(21)*, education is an effective tool for addressing health disparities and is associated with other socioeconomic factors such as employment, income, health insurance, and health care utilization *(9)*.

Examination of death rates and educational attainment provides information on the population groups that might be

focused or targeted for interventions. This analysis supports a previous study that reported associations between education and mortality (22). The majority of states with lower educational attainment exhibited high mortality rates both for all causes of death and HIV. Although higher mortality rates among persons with lower education reflect a complex causal pathway with confounding variables (22), given the importance of social determinants of health, *Healthy People* objectives specifically encourage programs and jurisdictions to collaborate in addressing education and other social determinants of health. Educational attainment is a socioeconomic variable that remains relatively constant throughout adulthood because the majority of persons achieve the required level before adulthood (23). As such, there is a long-term consequence on health.

Although educational attainment improved during the study period, states with the lowest education attainment are still at increased risk for death from all causes and HIV. One major finding of this report is that the risk for all causes of death was substantially greater among states with the least educated residents, compared with the states where residents are more educated. Lower educational attainment is associated with health risk factors (e.g., smoking, inadequate nutrition, lack of exercise, lack of access to high-quality medical care, and the inability to afford adequate housing and food) (19,24). States in the South and Midwest regions continue to record higher rates of smoking, despite tobacco being the leading cause of preventable diseases and death (25,26). Although the nation is experiencing improved educational attainment, medical care, and access to care, longitudinal studies are needed to determine whether people of all education levels are experiencing these improvements. To address health disparities, nonprofit organizations located in states with high mortality rates can take advantage of the Patient Protection and Affordable Care Act, which requires communities to conduct health assessments every 3 years to maintain their tax-exempt status (27). Key partners, including local public health departments, can help address health disparities by collaborating with nonprofit organizations which are working to improve education. States such as Rhode Island have found an achievement gap between Hispanic and White students (28). During 2018, education levels at or above high school completion were higher among White (90.2%) and Black (87.9%) persons than Hispanic persons (71.6%) in the United States (29). In the current analysis of data from 2017-2021, education levels at or above high school completion were higher among White (93.5%) and Black (87.2%) persons than Hispanic persons (71.2%). Texas, California, New Mexico, and Rhode Island have a high proportion of Hispanics and reduced statewide educational attainment. However, because of other intrinsic factors, these states recorded lower adjusted all-cause and HIV mortality rates. Lastly, although we found higher HIV mortality rates among males than females in all states, the rates recorded among both males and females in the District of Columbia were exceedingly higher. The 14 states where HIV mortality rates are higher than the national average of 3.3/100,000 population in males should institute strategies to address this disparity.

The findings in this report are subject to certain limitations. First, this study is ecological, and a causal relationship cannot be established. The aim was to assess educational attainment and mortality by state; intrastate variations, demographic characteristics, medical advances, health care access and lifestyle changes among the population groups at the state level were not assessed. Second, we did not adjust for race/ethnicity, differences between high and low HIV prevalence states, comorbidities, urban or rural states, substance abuse, Covid-19 mortality, and sex-related differences in deaths. Third, because mortality data were used, determining the stages of diseases (underlying cause of death) and whether deceased persons took appropriate clinical actions during the illness course (stages) could not be determined. A longitudinal study or retrospective review of medical records is needed to answer that question. Fourth, because educational information is inadequately captured on death certificates, we had to use educational data from another source. Using education from the death certificate might overestimate death rates for those with high school-level attainment (30). Fifth, we were unable to conduct regression analysis at the state level and determine specific contributions of education at this level because we lacked individual-level data on educational attainment. Improved educational data on decedents would be needed to conduct this type of analysis. For example, the surveillance system used by the tuberculosis program, which collects this type of information, could be used as a model for collecting educational data. Six, rather than examining all-cause mortality for the entire population, ages ≥25 years (18) were selected to correspond with the educational attainment data set. The rationale for this selection was that by aged 25 years, adults are expected to have completed their high school education or the equivalent. Seven, other socioeconomic factors (e.g., income), lifestyle changes, or available healthcare resources that might influence mortality were not included. However, education is a strong determinant of future employment and income and captures the influence of adult circumstances on their health (1,3,18,31).

Although ecological, this study echoes the relationship between educational attainment and mortality and the importance of reducing disparities in education to improve health (32). State health and education agencies should continue to collaborate on improving educational attainment for their residents.

Disclaimer: The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

Declaration of Conflicting Interests: Authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Data availability: The datasets used during analysis are available to the public at the referenced websites.

Funding: Authors received no funding for this work.

Authors' contributions: Nelson (conceptualization, writing, review and editing). Man-Huei (data analysis, review, and writing).

Consent for publication: Authors give permission for publication.

Ethics approval: This analytic study did not involve human subjects research supervised by an Institutional Review Board.

References:

1. Sasson I. Trends in life expectancy and lifespan variation by education attainment: United States, 1990–2010.

Demography 2016; 53:269–93.

2. Medina L, Sabo S, Vespa J. Living longer: historical and projected life expectancy in the United States, 1060 to 2060. US Census Bureau; 2020. Current Population Reports, P25-1145.

3. Kunst AE, Machenbach JP. The size of mortality differences associated with educational level in nine industrialized countries. Am J Public Health 1994; 84:932–7.

4. The Socio-economic Inequalities and HIV Working Group for Collaboration of Observational HIV Epidemiological Research in Europe (COHERE) in Euro-Coord. Inequalities by educational level in response to combination antiretroviral treatment and survival in HIV-positive men and women in Europe. AIDS 2017; 31:253-262.

5. Jarrin I, Lumbreras B, Feroros I, Perez-Hoyos S, Hurtado I, Hernandez-Aguado I. Effect of education on overall and cause-specific mortality in injecting drug users, according to HIV and introduction of HAART. Int J Epidemiol 2007; 36:187-194.

6. Simard EP, Fransua M, Naishdham D, Jemal A. The influence of sex, race/ethnicity, and educational attainment on human immunodeficiency virus death, rates among adults, 1993-2007. Arch Intern Med 2012; 172:1591-1598.

7. The impact of HIV/AIDS on education worldwide. Wiseman, Alexander W., 1968, Glover, Ryan N, (1st ed.). Bingley, UK: Emerald. 2012.

8. Centers for Disease Control and Prevention. Establishing a holistic framework to reduce inequalities in HIV, Viral Hepatitis, STDs, and Tuberculosis in the United States. Atlanta (GA): US Department of Health and Human Services, Centers for Disease Control and Prevention; October 2010.

9. Hahn RA, Truman BI. Education Improves Public Health and Promotes Health Equity. Int J Health Serv. 2015;45(4):657-78.

10. Social Determinants | Healthy People 2020 (archive-it.org). https://www.healthypeople.gov/2020/ Accessed August 21, 2023

11. https://www.health.healthypeople/priority-areas/social-determinants-health. Social Determinants of Health - Healthy People 2030 | health.gov. Accessed August 21, 2023

12. The White House. 2021. National HIV/AIDS Strategy for the United States 2022−2025. Washington, DC. Accessed August 21, 2023

13. Raghupathi, V., Raghupathi, W. The influence of education on health: an empirical assessment of OECD countries for the period 1995–2015. Arch Public Health 78, 20 (2020).

14. Centers for Disease Control and Prevention. Social determinants of health among adults with diagnosed HIV infection in the United States and Puerto Rico, 2020. HIV Surveillance Supplemental Report 2023;28(No. 2). Published March 2023. August 21, 2023.

15. Centers for Disease Control and Prevention. HIV Surveillance Report, 2020; vol. 33. Published May 2022. August 21, 2023.

16. Koenig LJ, Hoyer D, Purcell DW, Zaza S, Mermin J. Young people and HIV: a call to action. Am J Public Health 2016; 106:402-5.

17. Centers for Disease Control and Prevention, National Center for Health Statistics, National vital statistics system, mortality 2018-2021. Accessed August 21, 2023.

18. Gulati I, Kilian C, Buckley C, Mulia N, Probst C. Socioeconomic disparities in healthcare access and implications for all-cause mortality among US adults: a 2000-2019 record linkage study. American Journal of Epidemiology 2025; 194:432–40.

19. Langellier BA, Martínez-Donate AP, Gonzalez-Fagoaga JE, Rangel MG. The Relationship Between Educational Attainment and Health Care Access and Use Among Mexicans, Mexican Americans, and U.S.-Mexico Migrants. J Immigr Minor Health. 2020 Apr;22(2):314-322.

20. Feldman JJ, Makuc DM, Kleinman JC, Cornoni-Huntley J. National trends in educational differentials in mortality. Am J Epidemiol 1989; 129:919–33.

21. Galea S, Ahem J. Distribution of education and population health: an ecological analysis of New York City neighborhoods. Am J Public Health 2005; 95:2198–205.

22. Woolf SH, Johnson RE, Phillips RL, Philipsen M. Giving everyone the health of the educated: an examination of whether social change would save more lives than medical advances. Am J Public Health 2007; 97:679–83.

23. Montez JK, Hummer RA, Hayward MD. Educational attainment and adult mortality in the United States: a systematic analysis of functional form. Demography 2012; 49:315-336.

24. Montez JK, Zajacova A. Trends in mortality risk by education level and cause of death among US White women from 1986 to 2006. Am J Public Health 2013; 103:473–9.

25. Jamal A, Agaku IT, O'Connor E, King BA, Kenemer JB, Neff L. Current cigarette smoking among adults—United States, 2005–2013. MMWR Morb Mortal Wkly Rep 2014; 63:1108–12.

26. Cornelius ME, Lorelan CG, Jamal A, et al. Tobacco product use among adults—United States, 2021. MMWR Morb Mortal Wkly Rep 2023; 72:475-83.

27. Internal Revenue Service. New requirements for 501(c) (3) hospitals under the Affordable Care Act. Washington, DC: US Department of the Treasury, Internal Revenue Service; 2016. Accessed August 21, 2023

28. Latino students in Rhode Island. A review of local and national performances. lpi-education-report2013.pdf (rwu.edu). Accessed August 21, 2023

29. U.S.: educational attainment, by ethnicity 2018 | Statista. https://www.statista.com/statistics/184264/educational-attainment-by-enthnicity/ Accessed August 21, 2023

30. Sorlie PD, Johnson NJ. Validity of education information on the death certificate. Epidemiology 1996; 7:437–9.

31. Beckles GL, Truman BI. Education and income—United States, 2005 and 2009. MMWR Suppl 2011;60(Suppl 1):13–7.

32. Formagini T, Brooks JV, Roberts A, Bullard KM, Zhang Y, Saelee R, O'Brien MJ. Prediabetes prevalence and awareness by race, ethnicity, and educational attainment among US adults. Front. Public Health 2023; 11:1277657.