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All-Cause and Cause-Specific Mortality among US Youth: Socioeconomic and Rural–Urban Disparities and International Patterns

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ABSTRACT *We analyzed international patterns and socioeconomic and rural–urban disparities in all-cause mortality and mortality from homicide, suicide, unintentional injuries, and HIV/AIDS among US youth aged 15–24 years. A county-level socioeconomic deprivation index and rural–urban continuum measure were linked to the 1999–2007 US mortality data. Mortality rates were calculated for each socioeconomic and rural–urban group. Poisson regression was used to derive adjusted relative risks of youth mortality by deprivation level and rural–urban residence. The USA has the highest youth homicide rate and 6th highest overall youth mortality rate in the industrialized world. Substantial socioeconomic and rural–urban gradients in youth mortality were observed within the USA. Compared to their most affluent counterparts, youth in the most deprived group had 1.9 times higher all-cause mortality, 8.0 times higher homicide mortality, 1.5 times higher unintentional-injury mortality, and 8.8 times higher HIV/AIDS mortality. Youth in rural areas had significantly higher mortality rates than their urban counterparts regardless of deprivation levels, with suicide and unintentional-injury mortality risks being 1.8 and 2.3 times larger in rural than in urban areas. However, youth in the most urbanized areas had at least 5.6 times higher risks of homicide and HIV/AIDS mortality than their rural counterparts. Disparities in mortality differed by race and sex. Socioeconomic deprivation and rural–urban continuum were independently related to disparities in youth mortality among all sex and racial/ethnic groups, although the impact of deprivation was considerably greater. The USA ranks poorly in all-cause mortality, youth homicide, and unintentional-injury mortality rates when compared with other industrialized countries.*

KEYWORDS *Youth mortality, Homicide, Suicide, Injury, HIV/AIDS, Deprivation index, Rural–urban, Race/ethnicity, United States, International pattern*

INTRODUCTION

Youth aged 15-24 years, also referred to as adolescents and young adults, are a major demographic group in the USA, with a population of 43.2 million or 14.1 % of the total US population.[1–3] Premature deaths among youth from preventable

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causes such as homicide, suicide, and motor vehicle accidents (MVA) contribute greatly to the years of potential life lost.[1,2,4]

During the past four decades, youth mortality in the USA has declined at a modest pace.[1,2,4] The overall trend in youth mortality has been characterized by two countervailing trends—a consistently downward trend in unintentional-injury mortality and a fluctuating but slightly upward trend in homicide and suicide mortality during the past four decades.[1,2] Unintentional injuries (including MVA), homicide, and suicide are the three leading causes of youth mortality, and risks of mortality from homicide, MVA, and firearm injuries among youth exceed those for the other age groups.[2,4] Higher mortality risks among youth, especially from homicide, crime victimization, and suicide, are often linked to adverse social and economic conditions as youth are more likely than other groups to experience higher levels of poverty, unemployment, social disruption, migration, and risky behaviors (e.g., smoking, heavy drinking, and drug use), and lower levels of social participation and civic engagement.[1–5]

Research examining socioeconomic and rural–urban disparities in youth mortality is limited in the USA. One previous US study examined trends in youth mortality by leading causes of death, race/ethnicity, and socioeconomic factors from 1950 through 1993,[1] while another study looked at long-term trends in youth mortality from 1935 to 2007 according to sex, race/ethnicity, cause of death, and state of residence.[2] Although long-term trends in youth suicide and homicide rates have been related to unemployment and economic trends,[6–8] the extent to which youth mortality rates from leading causes of death vary in relation to area deprivation levels have not yet been examined. Moreover, to our knowledge, only one US study has examined rural–urban patterns in suicide risks among male and female youth.[9] Rural–urban disparities in overall youth mortality or mortality from other causes are not known. In this paper, using the 1999–2007 national mortality data, we analyze socioeconomic and rural–urban disparities in all-cause mortality and mortality from such leading causes of death as homicide, suicide, unintentional injuries, and HIV/AIDS among US youth aged 15–24. While this study focuses on disparities within the USA, we begin by presenting a cross-national comparison of the latest youth mortality statistics in 45 industrialized countries to provide an international context for the magnitude of the problem facing the American youth.

METHODS

Data for international comparisons of youth mortality came from the WHO mortality database.[10] To analyze socioeconomic and rural–urban disparities in youth mortality within the USA, we used three national data sources: the national mortality database, the 2000 census, and the 2009–2010 Area Resource File (ARF).[4,11–14] The national mortality database provided the pooled mortality data for the time period 1999–2007 by age, sex, race, and cause of death at the county level.[11,12] Specifically, mortality rates for youth aged 15–24 were computed for the total population and for non-Hispanic whites, blacks, American Indians and Alaska Natives (AIAN), Asians/Pacific Islanders, and Hispanics. Mortality rates were computed for all causes combined and for unintentional injuries (including MVA), homicide, suicide, and HIV/AIDS.

Constructing a Modified Deprivation Index for the 2000 US Census

Since the vital-statistics-based national mortality database lacks reliable individual- or household-level socioeconomic data, socioeconomic patterns in youth mortality were

examined by linking a census-based deprivation index with the national mortality data at the county level.[15–18] Details of the linkage methodology are provided elsewhere.[15–18]

We constructed a factor-based deprivation index that consisted of 22 census-based socioeconomic indicators shown in Table 1, which may be viewed as broadly representing educational opportunities, labor force skills, economic, and housing conditions in a given county.[15–17] Selected indicators of education, occupation, wealth, income distribution, unemployment rate, poverty rate, and housing quality were used to construct the index.[15–17]

Since the US deprivation index was originally constructed for the 1990 census by using socioeconomic indicators at the census-tract level,[15,16,18] we selected theoretically relevant variables for index construction using census tract data from the 2000 census.[13] An earlier version of the deprivation index for the 2000 census consisted of 11 socioeconomic indicators.[17] We updated the deprivation index by applying factor and principal components analysis to 22 census-tract indicators

TABLE 1 Factor loadings for the 22 socioeconomic variables comprising the area socioeconomic deprivation Index, USA, 2000 Census

Socioeconomic variable	Census Tract Index	Zip Code Index	County Index
Education			
%Population aged 25+ years with <9 years of education	−0.70	−0.67	−0.73
%Population aged 25+ years with at least a high school diploma	0.85	0.79	0.84
Occupation and employment			
%Employed persons aged 16+ in white collar occupations	0.76	0.65	0.64
%Civilian labor force population aged 16+ unemployed[a]	−0.68	−0.53	−0.60
Income distribution, inequality, and wealth			
Median family income ($)	0.87	0.86	0.90
Income disparity[b]	−0.85	−0.79	−0.86
Median home value ($)	0.55	0.63	0.67
Median gross rent ($)	0.62	0.61	0.69
Median monthly mortgage ($)	0.61	0.67	0.69
Median annual real estate taxes ($)	0.60	0.67	0.67
Poverty and Welfare Assistance			
%Families below poverty level	−0.86	−0.77	−0.89
%Population below 150 % of the poverty threshold	−0.92	−0.86	−0.92
%Households receiving supplemental security income	−0.74	−0.60	−0.82
%Households receiving public assistance income	−0.74	−0.58	−0.64
%Single-parent households with children aged <18 years	−0.69	−0.43	−0.48
Housing tenure, housing quality, and transport			
%Households without a motor vehicle	−0.63	−0.47	−0.49
%Households without a telephone	−0.65	−0.59	−0.79
%Owner-occupied housing units (home ownership rate)	0.59	0.24	−0.02
%Occupied housing units lacking complete plumbing facilities (log)	−0.39	−0.29	−0.52
%Households with more than one person per room (crowding)	−0.55	−0.44	−0.38
Median number of rooms per housing unit	0.69	0.62	0.58
%Housing units with 4 or more bedrooms	0.66	0.57	0.62
Proportion of total variance explained by factor	0.49	0.39	0.47
Factor-based Cronbach's alpha (reliability coefficient)	0.95	0.93	0.95

Factor loadings were derived from principal components analyses of the 2000 census data for 64,869 census tracts, 31,854 Zip Code Tabulation Areas (ZCTAs), and 3,141 counties. Higher index scores denote higher socioeconomic status levels and lower levels of deprivation

[a]Unemployment rate

[b]Income disparity was defined as the log of 100*ratio of number of households with <$15,000 income to number of households with $75,000+ income

from the 2000 census. The factor loadings (correlations of indicators with the index) for the census-tract index ranged from 0.92 for 150 % of the poverty rate to 0.39 for household plumbing (Table 1). The deprivation index was then constructed at the county and zip-code levels by factor-analyzing the same variables as those comprising the census-tract index. Home ownership did not load on the county deprivation index, while all other variables loaded similarly on the county index, with poverty rate, median family income, income inequality, and education having the highest relative weights (Table 1). As was observed for the 1990 deprivation index, the factor loadings for the indicators comprising the 2000 index at the three geographic levels were generally similar in magnitude and relative importance.[15,16]

Factor loadings in Table 1 represent the relative weights of the 22 indicators making up the index. The deprivation index was standardized to have a mean value of 100 and a standard deviation of 20. Higher index scores denote higher levels of socioeconomic status and lower levels of deprivation. The index score varied from a high of 171.9 for Douglas County, Colorado to a low of 7.6 for Wade Hampton Census Area in Alaska. Substantive and methodological details of the original US deprivation index are provided elsewhere.[15–18]

In order to compute mortality rates by deprivation level, we used the weighted population decile distribution of the deprivation index that classified all 3,141 US counties into 10 groups of approximately equal population size.[17] The groups thus created ranged from being the most-deprived (first decile) to the least-disadvantaged (tenth decile) population groups.[17] A majority of the deprived counties were concentrated in the Southeastern region, whereas many of the affluent counties were located in the Northeastern and Western regions of the USA (Figure 1). Each of the 3,141 counties in the mortality database was assigned one of the ten deprivation categories. To simplify analysis and data presentation, we combined the 4th through 7th deciles of the deprivation index since mortality rates did not vary greatly among these middle deprivation categories.

To analyze rural–urban disparities in youth mortality, we used the 2003 rural–urban continuum variable that was developed by the US Department of Agriculture.[9,14,19] This variable classifies all US counties into 9 distinct groups in the order of decreasing urbanization levels or increasing levels of rurality, based on the population size of the counties and their proximity to metropolitan areas.[14] The 9 categories are defined as follows: (1) most urban=counties in metropolitan areas of 1 million population or more; (2) 2nd most urban=counties in metropolitan areas of 250,000–1,000,000 population; (3) 3rd most urban=counties in metropolitan areas of less than 250,000 population; (4) 4th most urban=urban non-metropolitan counties with population of 20,000 or more, adjacent to a metropolitan area; (5) 5th most urban=urban non-metropolitan counties with population of 20,000 or more, not adjacent to a metropolitan area; (6) 6th most urban=urban non-metropolitan counties with population of 2,500–19,999, adjacent to a metropolitan area; (7) 7th most urban=urban non-metropolitan counties with population of 2,500–19,999, not adjacent to a metropolitan area; (8) 2nd most rural=rural counties with a population of <2,500, adjacent to a metropolitan area; and (9) most rural=rural counties with a population of <2,500, not adjacent to a metropolitan area. For the purposes of computing mortality rates, we collapsed these 9 continuum categories into 5 rural–urban groups: large metropolitan county-group (code 1); medium metropolitan county-group (code 2); small metropolitan county-group (code 3); urban non-metropolitan county-group (codes 4–7); and rural non-metropolitan county group (codes 8 and 9). The number of counties in these 5 rural–urban groups

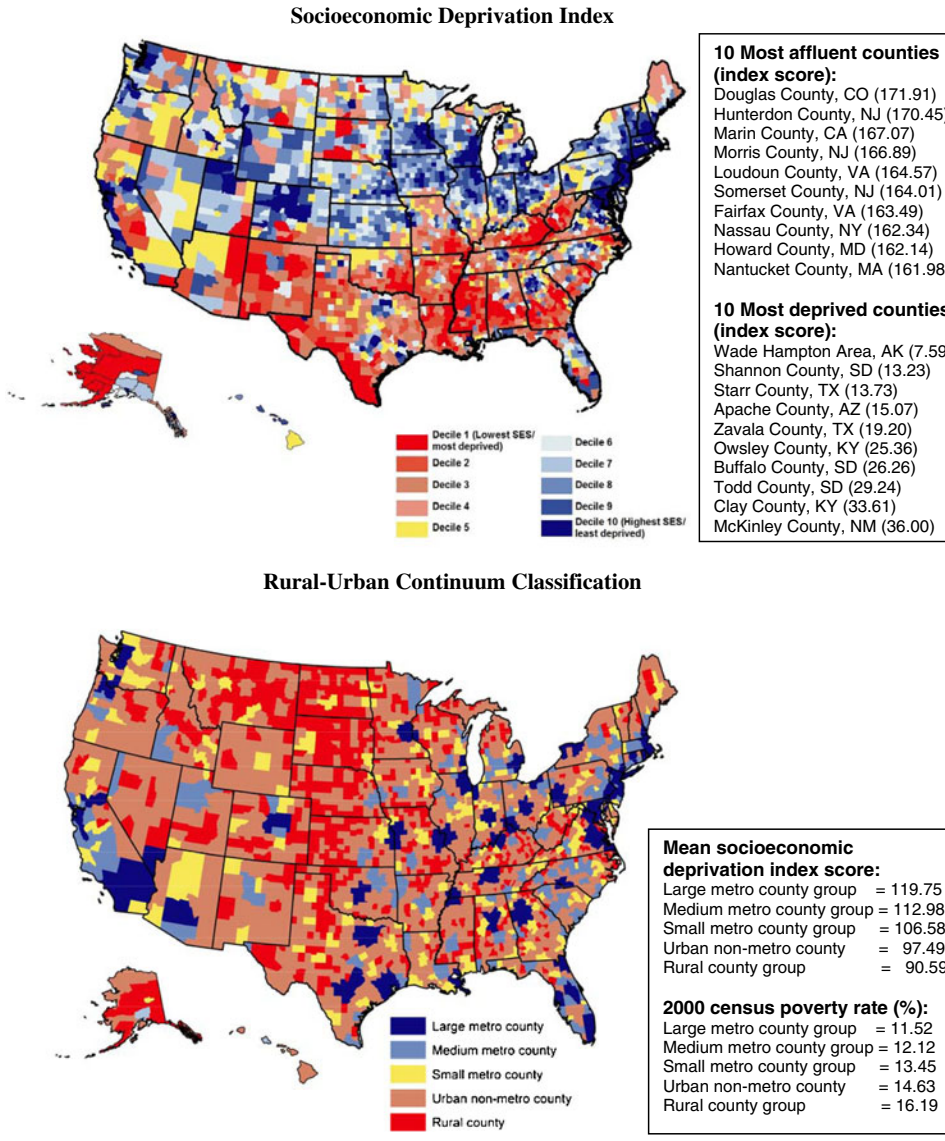

FIGURE 1. The 2000 county socioeconomic deprivation index and the 2003 rural–urban continuum classification for the USA (3,141 counties).

were 414, 325, 351, 1,381, and 670, respectively. The 5 rural–urban groups accounted for 53.6 %, 20.0 %, 9.9 %, 14.9 %, and 1.7 % of the total US population in 2007, respectively.[14] Most of the non-metropolitan and rural counties are in the Midwest and the Great Plains regions of the USA, whereas many of the large metropolitan counties are located in the Northeast (Figure 1).

Sex-race-county-specific population estimates from 1999 to 2007 served as denominators for computing average annual mortality rates.[4,11,13] There were 220,016 male and 77,337 female deaths that occurred among the US youth during 1999–2007. Since the input data in our study were aggregate death and population counts for youth at the county level, we used Poisson regression models, estimated by the SAS GENMOD procedure, to derive relative risks of all-cause and cause-

specific youth mortality for each socioeconomic and rural–urban group.[20,21] Analyses were stratified by sex and race/ethnicity. Differences in mortality rates and relative risks were tested for statistical significance at the 0.05 level. In all regression models, the highest socioeconomic group and the most-urbanized-county group (large metropolitan counties) were selected as the reference categories.

RESULTS

International Disparities in Youth Mortality

Figure 2 provides a comparison of youth mortality rates in 45 selected OECD and industrialized countries. The USA has the 6th highest overall youth mortality rate, with youth in only Russia, Ukraine, Estonia, Mexico, and Argentina having a higher mortality rate. The all-cause mortality rate in the USA is two to three times higher than that in England and Wales, Japan, Sweden, Germany, and the Netherlands. The USA has the highest youth homicide rate at 13.3 per 100,000 population, which is 5.3 times higher than the rate for Canada and 13.3 times higher than the rate for Sweden. The USA ranks in the middle in youth suicide; it has a significantly lower suicide rate than Finland, New Zealand, Ireland, and Japan, but has a substantially higher suicide rate than that for Italy, England and Wales, Germany, the Netherlands, France, and Mexico. In terms of youth mortality from unintentional injuries, the USA has the 5th highest rate, exceeded only by Russia, Ukraine, Estonia, and Greece.

Disparities in All-Cause Youth Mortality

Geographical distributions in socioeconomic deprivation and all-cause youth mortality rates were closely related (weighted correlation = 0.50), with mortality rates, like deprivation levels, being substantially higher in the Southeast and lower in the Northeast. There was a consistent gradient in all-cause youth mortality by socioeconomic deprivation levels. Youth in the most deprived group had a 93 % higher mortality rate than those in the least deprived group (Table 2). Socioeconomic gradients were similar for males and females. Since the deprivation index and rural–urban continuum were substantially correlated (weighted correlation = 0.40), it is important to identify mortality patterns for each factor while controlling for the other. Adjustment for urbanization level had little impact on the magnitude of socioeconomic disparities, with young men and women, respectively, having 104 % and 62 % higher all-cause mortality in the most deprived group than their counterparts in the least deprived group (Table 2).

Higher levels of rurality were associated with higher youth mortality rates in both males and females. Adjustment for deprivation levels accounted for some of the rural–urban differences in mortality. Regardless of deprivation levels, young men and women in rural areas experienced 17 % and 59 % higher mortality risks than their counterparts in the most urbanized areas, respectively (Table 2).

During 1999–2007, mortality rates were significantly higher among black and AIAN youth and significantly lower among Asian/Pacific Islanders compared to non-Hispanic whites. Although both socioeconomic deprivation and urbanization levels were independently related to disparities in mortality among youth of all races and ethnicities, the strength of the associations varied. After adjusting for urbanization levels, AIAN, black, and non-Hispanic white youth in the most

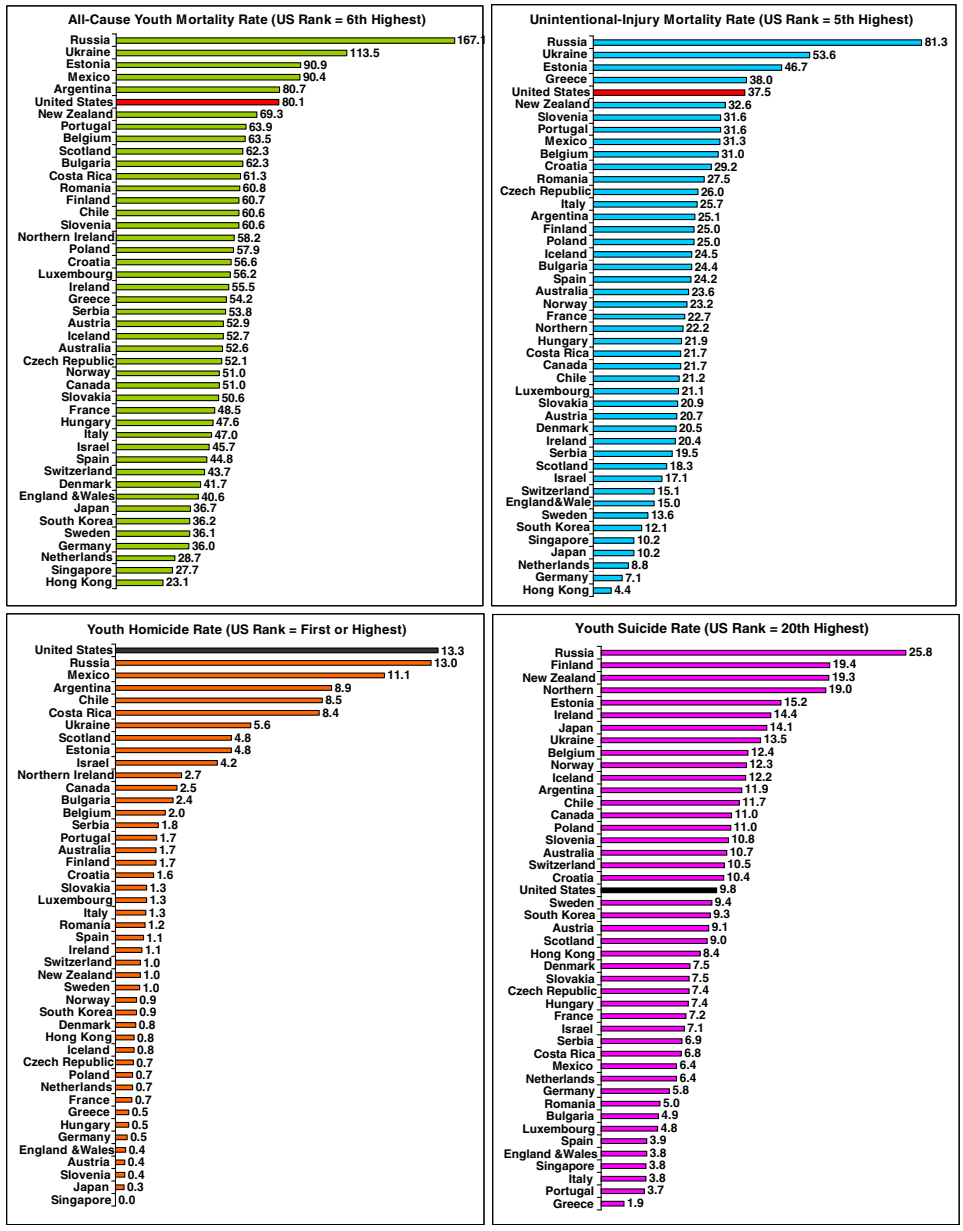

FIGURE 2. All-cause and cause-specific mortality rates per 100,000 population, youth aged 15–24 years, selected OECD and industrialized countries, 2003–2007. Mortality data for Belgium are for 1997. Data for Iceland are for the period 2004–2006 and for Luxembourg for the period 2003–2005. Data for all other countries are for a single calendar year between 2003 and 2007. *OECD* Organization for Economic Cooperation and Development. Source: WHO Mortality Database, 2011 (http://www.who.int/healthinfo/morttables/en/).

deprived areas had about twice the mortality risk of their counterparts in the least deprived group (Table 2).

Rural youth in all racial/ethnic groups except blacks had significantly higher all-cause mortality rates than their most urbanized counterparts. Rural–urban differ-

TABLE 2 All-cause youth mortality rates per 100,000 population and relative risk (RR) of mortality derived from Poisson regression models according to socioeconomic deprivation deciles and five rural–urban categories, USA, 1999–2007

	Mortality		Unadj.	Adjusted		Mortality		Unadj.	Adjusted		Mortality		Unadj.	Adjusted	
	Rate	SE	RR	RR	95 % CI	Rate	SE	RR	RR	95 % CI	Rate	SE	RR	RR	95 % CI
	Total population					All males					All females				
All groups	80.86	0.15				116.53	0.25				43.22	0.16			
Socioeconomic deprivation index															
Socioeconomic decile 1	111.65	0.54	1.93*	1.90	1.87–1.94	161.83	0.92	1.98*	2.04	2.00–2.09	58.83	0.57	1.82*	1.62	1.56–1.67
Socioeconomic decile 2	99.49	0.57	1.72*	1.73	1.70–1.77	140.51	0.95	1.72*	1.81	1.77–1.85	55.53	0.62	1.72*	1.55	1.50–1.61
Socioeconomic decile 3	81.78	0.43	1.41*	1.43	1.40–1.45	119.40	0.72	1.46*	1.51	1.48–1.54	41.93	0.44	1.30*	1.25	1.21–1.29
Socioeconomic deciles 4–7	81.56	0.23	1.41*	1.44	1.42–1.46	118.10	0.39	1.44*	1.51	1.48–1.54	43.21	0.24	1.34*	1.29	1.25–1.33
Socioeconomic decile 8	67.63	0.43	1.17*	1.20	1.18–1.23	96.62	0.71	1.18*	1.24	1.21–1.27	37.06	0.45	1.15*	1.12	1.08–1.17
Socioeconomic decile 9	63.98	0.42	1.11*	1.12	1.10–1.14	91.86	0.70	1.12*	1.15	1.12–1.18	34.70	0.44	1.07*	1.07	1.03–1.11
Socioeconomic decile 10	57.89	0.42	1.00	1.00	Reference	81.83	0.70	1.00	1.00	Reference	32.28	0.45	1.00	1.00	Reference
Rural–urban continuum category															
Large metro counties[a]	77.51	0.20	1.00	1.00	Reference	114.12	0.34	1.00	1.00	Reference	39.24	0.21	1.00	1.00	Reference
Medium metro counties[b]	77.21	0.32	1.00	0.94	0.93–0.95	110.74	0.54	0.97*	0.91	0.90–0.92	42.01	0.34	1.07*	1.02	1.00–1.04
Small metro counties[c]	74.63	0.43	0.96*	0.87	0.86–0.88	104.98	0.71	0.92*	0.82	0.81–0.83	42.53	0.46	1.08*	1.00	0.97–1.02
Urban non-metro counties[d]	96.67	0.41	1.25*	1.04	1.02–1.05	134.39	0.67	1.18*	0.96	0.95–0.97	55.63	0.45	1.42*	1.22	1.19–1.24
Rural counties[e]	126.66	1.47	1.63*	1.29	1.26–1.32	172.55	2.36	1.51*	1.17	1.14–1.20	75.51	1.65	1.92*	1.59	1.52–1.66
	Non-Hispanic Whites					All Blacks					Black males				
All Groups	74.73	0.18				114.18	0.45				173.95	0.78			
Socioeconomic deprivation index															
Socioeconomic decile 1	112.15	0.24	1.95*	1.74	1.70–1.78	128.90	1.14	1.67*	1.93	1.84–2.01	197.38	1.99	1.71*	2.16	2.05–2.27
Socioeconomic decile 2	96.46	0.22	1.68*	1.54	1.50–1.58	118.11	1.41	1.53*	1.81	1.72–1.89	174.51	2.40	1.51*	1.94	1.84–2.05
Socioeconomic decile 3	78.68	0.20	1.37*	1.31	1.28–1.34	117.17	1.34	1.52*	1.63	1.56–1.71	178.98	2.34	1.55*	1.72	1.63–1.81
Socioeconomic deciles 4–7	74.01	0.27	1.29*	1.25	1.22–1.27	117.24	0.72	1.52*	1.62	1.55–1.69	180.08	1.26	1.56*	1.71	1.63–1.79
Socioeconomic decile 8	63.82	0.49	1.11*	1.09	1.06–1.12	100.12	1.59	1.30*	1.37	1.30–1.44	153.37	2.77	1.33*	1.43	1.35–1.52
Socioeconomic decile 9	59.96	0.49	1.04*	1.04	1.01–1.06	94.95	1.47	1.23*	1.26	1.20–1.33	143.17	2.55	1.24*	1.28	1.21–1.36
Socioeconomic decile 10	57.54	0.51	1.00	1.00	Reference	77.17	1.56	1.00	1.00	Reference	115.61	2.68	1.00	1.00	Reference
Rural–urban continuum category															
Large metro counties	67.28	0.26	1.00*	1.00	Reference	121.41	0.59	1.00	1.00	Reference	192.73	1.06	1.00	1.00	Reference
Medium metro counties	71.86	0.38	1.07*	1.02	1.01–1.03	105.56	1.03	0.87*	0.85	0.83–0.87	156.81	1.76	0.81*	0.79	0.77–0.81

Small metro counties	70.64	0.48	1.05*	0.95	0.94–0.97	93.90	1.42	0.77*	0.71	0.69–0.73	132.47	2.36	0.69*	0.63	0.60–0.65
Urban non-metro counties	93.27	0.46	1.39*	1.15	1.14–1.17	102.63	1.27	0.85*	0.72	0.70–0.74	136.52	2.00	0.71*	0.58	0.56–0.60
Rural counties	121.05	1.60	1.80*	1.41	1.37–1.45	117.83	4.42	0.97	0.80	0.74–0.86	142.23	6.53	0.74*	0.58	0.53–0.63
	Hispanics					American Indians and Alaska Natives					Asians and Pacific Islanders				
All Groups	77.21	0.35				105.65	1.45				41.54	0.49			
Socioeconomic deprivation index															
Socioeconomic decile 1	80.68	0.92	1.40*	1.24	1.18–1.30	171.6	3.57	5.58*	2.44	1.86–3.20	55.93	2.46	1.71*	1.52	1.36–1.70
Socioeconomic decile 2	83.47	1.33	1.44*	1.30	1.24–1.37	140.3	4.78	4.56*	2.26	1.72–2.98	60.35	3.25	1.84*	1.49	1.30–1.70
Socioeconomic decile 3	76.49	0.78	1.32*	1.31	1.25–1.37	60.43	3.13	1.97*	1.32	1.00–1.75	39.19	1.12	1.20*	1.17	1.08–1.28
Socioeconomic deciles 4–7	82.95	0.62	1.44*	1.39	1.33–1.45	80.39	2.20	2.61*	1.88	1.44–2.45	41.13	0.91	1.25*	1.17	1.08–1.27
Socioeconomic decile 8	71.09	1.34	1.23*	1.17	1.11–1.24	72.57	4.80	2.36*	1.77	1.32–2.37	44.46	1.31	1.36*	1.25	1.14–1.37
Socioeconomic decile 9	63.81	1.14	1.10*	1.08	1.03–1.14	53.93	4.17	1.75*	1.56	1.15–2.10	40.88	1.37	1.25*	1.20	1.09–1.31
Socioeconomic decile 10	57.77	1.14	1.00	1.00	Reference	30.75	4.15	1.00	1.00	Reference	32.79	1.12	1.00	1.00	Reference
Rural–urban continuum category															
Large metro counties	73.26	0.42	1.00	1.00	Reference	51.64	1.72	1.00	1.00	Reference	38.07	0.56	1.00	1.00	Reference
Medium metro counties	79.89	0.82	1.09*	1.10	1.07–1.13	73.12	2.78	1.42*	1.22	1.10–1.35	50.28	1.28	1.32*	1.26	1.18–1.35
Small metro counties	80.16	1.34	1.09*	1.08	1.04–1.12	110.96	4.31	2.15*	1.76	1.58–1.96	42.29	2.10	1.11*	1.04	0.94–1.16
Urban non-metro counties	100.92	1.49	1.38*	1.36	1.32–1.41	162.13	3.30	3.14*	2.36	2.15–2.59	58.29	2.69	1.53*	1.55	1.41–1.71
Rural counties	114.43	6.67	1.56*	1.54	1.37–1.72	254.04	9.94	4.92*	3.63	3.24–4.07	107.48	22.41	2.82*	2.34	1.55–3.53

For estimating relative risks of mortality, the tenth socioeconomic decile and large metro counties were treated as reference categories

*$P<0.05$. Decile 1 of the socioeconomic deprivation index represents the most deprived group and decile 10 the least deprived group

[a]Counties in metropolitan areas with 1 million population or more

[b]Counties in metropolitan areas of 250,000–1,000,000 population

[c]Counties in metropolitan areas with population <250,000

[d]Urban nonmetropolitan counties

[e]Rural counties with no places with a population of 2,500+

ences were most pronounced among AIAN youth. After adjusting for deprivation levels, AIAN youth in rural areas had 3.6 times higher mortality than their counterparts in large metropolitan areas. On the other hand, black youth in rural areas and small-urban towns had an approximately 20–30 % lower mortality than their counterparts from large metropolitan areas.

Disparities in Youth Mortality from Homicide, Suicide, Unintentional Injuries, and HIV/AIDS

Geographic patterns in youth homicide rates in Figure 3 were related to those in deprivation, with youth in the Southeastern and Southwestern USA being at substantially higher risks of homicide (correlation=0.32). Both deprivation and urbanization levels contributed independently to geographic disparities in youth homicide rates among males as well as females. Deprivation gradients in homicide mortality among young men were especially marked, with those in the most deprived group experiencing 9.3 times higher risk of homicide than those in the most affluent group. Even after adjusting for deprivation levels, young men in large and medium-size metropolitan counties had 7.2 and 3.3 times higher homicide rates than those in rural areas (Table 3).

Geographic patterns in Figure 4 indicate higher youth suicide rates in the Western region than elsewhere in the USA (correlation with rurality=0.27). Although youth suicide rates were generally higher in more deprived areas, suicide was related to increased deprivation only among young men after controlling for rurality (Table 3). After adjusting for deprivation levels, youth in rural areas had 84 % higher suicide mortality than their most urbanized counterparts.

Geographic patterns in unintentional injury mortality were related to both deprivation (correlation=0.36) and rurality (correlation=0.54), with youth in the Southeastern and Mountain regions having higher death rates (Figure 3). After controlling for rurality, higher deprivation levels were associated with higher risks of unintentional injury mortality. After adjusting for deprivation levels, male and female youth in rural areas had, respectively, 2.1 and 2.7 times higher unintentional injury mortality than their most urbanized counterparts (Table 3).

Since deaths from MVA accounted for 71.5 % of all unintentional injury deaths during 1999-2007, socioeconomic and rural–urban patterns in MVA mirror those in the overall unintentional-injury mortality. According to the adjusted Poisson models (not shown here), male and female youth in the most deprived group had, respectively, 51 % and 44 % higher MVA mortality than their counterparts in the least deprived group, whereas male and female youth in rural areas had, respectively, 2.4 and 3.1 times higher MVA mortality than their most urbanized counterparts.

Geographical patterns indicate higher HIV/AIDS mortality in the Southeast, with moderate but statistically significant correlations with deprivation and rural–urban continuum (Figure 4). According to the regression models in Table 3, both deprivation and urbanization levels were strongly related to HIV/AIDS mortality among youth. After controlling for rural–urban residence, young males and females in the most deprived group had 6.3 and 14.9 times higher risk of HIV/AIDS mortality than their most affluent counterparts, respectively. HIV/AIDS mortality was considerably higher in urban than in rural areas. After adjusting for deprivation levels, young males and females in large metropolitan areas had 4.1 and 9.3 times higher risks of HIV/AIDS mortality than their most rural counterparts.

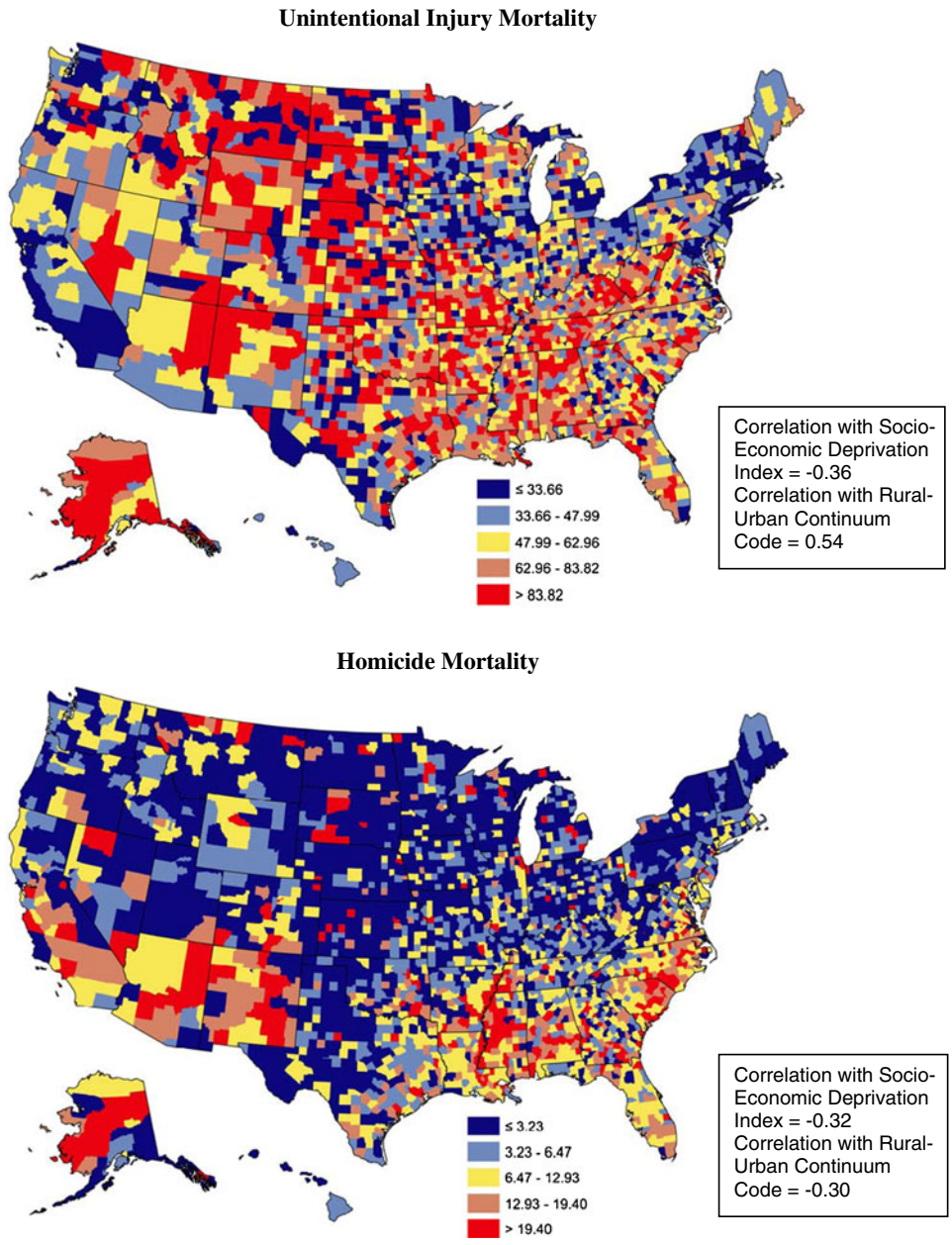

FIGURE 3. Unintentional injury mortality and homicide mortality rates per 100,000 population, US youth aged 15–24 years, 1999–2007 (3,141 counties).

DISCUSSION

In this study, we used a comprehensive area-based deprivation index and a rural–urban continuum measure to determine socioeconomic and rural–urban disparities in youth mortality in the USA. To our knowledge, our study is the first to examine the independent effects of both deprivation and urbanization on all-cause mortality and mortality from homicide, suicide, unintentional injuries, and HIV/AIDS among

TABLE 3 Cause-specific youth mortality rates per 100,000 population and relative risk (RR) of mortality derived from Poisson regression models according to socioeconomic deprivation deciles and five rural–urban categories, USA, 1999–2007

	Total Population					Male					Female				
	Mortality		Unadj.	Adjusted		Mortality		Unadj.	Adjusted		Mortality		Unadj.	Adjusted	
	Rate	SE	RR	RR	95 % CI	Rate	SE	RR	RR	95 % CI	Rate	SE	RR	RR	95 % CI
Homicide mortality															
Socioeconomic deprivation index															
Socioeconomic decile 1	21.14	0.24	3.86*	7.96	7.55–8.39	36.55	0.44	4.18*	9.32	8.81–9.87	4.91	0.16	2.48*	3.53	3.09–4.03
Socioeconomic decile 2	14.33	0.22	2.61*	5.76	5.45–6.10	23.46	0.39	2.68*	6.38	5.99–6.78	4.54	0.18	2.29*	3.38	2.94–3.88
Socioeconomic decile 3	17.94	0.20	3.27*	4.37	4.16–4.61	30.74	0.37	3.51*	4.82	4.56–5.10	4.38	0.14	2.21*	2.56	2.26–2.91
Socioeconomic deciles 4–7	13.58	0.10	2.48*	3.55	3.38–3.73	22.66	0.17	2.59*	3.82	3.62–4.03	4.06	0.07	2.05*	2.46	2.19–2.76
Socioeconomic decile 8	8.33	0.15	1.52*	2.17	2.04–2.30	13.86	0.27	1.58*	2.33	2.19–2.49	2.50	0.12	1.26*	1.50	1.30–1.74
Socioeconomic decile 9	8.34	0.15	1.52*	1.73	1.64–1.84	13.92	0.27	1.59*	1.83	1.72–1.95	2.48	0.12	1.25*	1.33	1.15–1.54
Socioeconomic decile 10	5.48	0.13	1.00	1.00	Reference	8.75	0.23	1.00	1.00	Reference	1.98	0.11	1.00	1.00	Reference
Rural–urban continuum category															
Large metro counties	18.01	0.10	3.00*	5.67	5.09–6.30	31.16	0.18	3.63*	7.23	6.39–8.18	4.27	0.07	1.36*	2.02	1.63–2.51
Medium metro counties	10.11	0.12	1.68*	2.77	2.49–3.09	16.50	0.21	1.92*	3.30	2.91–3.73	3.39	0.10	1.08*	1.46	1.17–1.82
Small metro counties	6.64	0.13	1.10*	1.58	1.41–1.77	10.21	0.22	1.19*	1.76	1.54–2.00	2.85	0.12	0.91*	1.11	0.88–1.39
Urban non-metro counties	6.53	0.11	1.09*	1.24	1.11–1.38	9.75	0.18	1.14*	1.31	1.16–1.49	3.02	0.11	0.96	1.03	0.82–1.28
Rural counties	6.01	0.32	1.00	1.00	Reference	8.59	0.53	1.00*	1.00	Reference	3.13	0.34	1.00*	1.00	Reference
Suicide mortality															
Socioeconomic deprivation index															
Socioeconomic decile 1	10.81	0.17	1.37*	1.09	1.04–1.15	18.06	0.31	1.45*	1.15	1.08–1.21	3.17	0.13	1.07*	0.94	0.83–1.07
Socioeconomic decile 2	11.45	0.19	1.45*	1.18	1.12–1.24	19.06	0.35	1.53*	1.23	1.16–1.30	3.29	0.15	1.11*	1.00	0.87–1.14
Socioeconomic decile 3	9.08	0.14	1.15*	1.04	0.99–1.10	14.99	0.26	1.20*	1.08	1.02–1.14	2.82	0.11	0.95	0.91	0.80–1.03
Socioeconomic deciles 4–7	10.50	0.05	1.33*	1.20	1.15–1.25	17.40	0.15	1.39*	1.25	1.19–1.31	3.26	0.07	1.10*	1.04	0.94–1.16
Socioeconomic decile 8	9.94	0.16	1.26*	1.15	1.10–1.22	16.27	0.29	1.30*	1.19	1.12–1.26	3.28	0.13	1.11*	1.06	0.94–1.20
Socioeconomic decile 9	8.76	0.15	1.11*	1.07	1.01–1.13	14.22	0.28	1.14*	1.09	1.03–1.16	3.02	0.13	1.02	1.00	0.88–1.13
Socioeconomic decile 10	7.88	0.16	1.00	1.00	Reference	12.48	0.27	1.00	1.00	Reference	2.96	0.14	1.00	1.00	Reference
Rural–urban continuum category															
Large metro counties	8.82	0.07	1.00	1.00	Reference	14.39	0.12	1.00	1.00	Reference	3.00	0.06	1.00	1.00	Reference
Medium metro counties	10.19	0.12	1.16*	1.12	1.09–1.15	16.84	0.21	1.17*	1.13	1.09–1.16	3.20	0.09	1.07*	1.05	0.98–1.13
Small metro counties	10.55	0.16	1.20	1.16	1.12–1.20	17.56	0.29	1.22	1.17	1.13–1.22	3.14	0.13	1.05*	1.05	0.96–1.15

Urban non-metro counties	12.53	0.15	1.42*	1.39	1.35–1.43	20.86	0.27	1.45*	1.40	1.36–1.45	3.47	0.11	1.16*	1.17	1.08–1.27
Rural counties	16.47	0.53	1.87*	1.84	1.72–1.97	26.92	0.93	1.87*	1.82	1.70–1.96	4.82	0.42	1.61*	1.65	1.38–1.98
Unintentional injury mortality															
Socioeconomic deprivation index															
Socioeconomic decile 1	53.32	0.38	2.04*	1.47	1.43–1.51	76.95	0.63	2.02*	1.49	1.45–1.54	28.44	0.39	2.14*	1.44	1.36–1.52
Socioeconomic decile 2	50.29	0.41	1.92*	1.41	1.37–1.45	71.61	0.68	1.88*	1.42	1.38–1.47	27.45	0.43	2.07*	1.42	1.34–1.50
Socioeconomic decile 3	33.83	0.28	1.29*	1.13	1.10–1.16	49.22	0.46	1.29*	1.14	1.10–1.18	17.53	0.28	1.32*	1.11	1.05–1.17
Socioeconomic deciles 4–7	37.06	0.16	1.42*	1.22	1.19–1.25	54.05	0.27	1.42*	1.24	1.21–1.28	19.24	0.16	1.45*	1.21	1.15–1.26
Socioeconomic decile 8	31.48	0.29	1.20*	1.06	1.03–1.10	45.23	0.49	1.19*	1.06	1.03–1.10	16.99	0.31	1.28*	1.10	1.04–1.16
Socioeconomic decile 9	28.59	0.28	1.09*	1.04	1.01–1.07	42.03	0.47	1.10*	1.06	1.02–1.09	14.47	0.29	1.09*	1.03	0.97–1.09
Socioeconomic decile 10	26.13	0.28	1.00	1.00	Reference	38.13	0.48	1.00	1.00	Reference	13.29	0.29	1.00	1.00	Reference
Rural–urban continuum category															
Large metro counties	29.74	0.13	1.00	1.00	Reference	43.87	0.21	1.00	1.00	Reference	14.96	0.13	1.00	1.00	Reference
Medium metro counties	36.87	0.22	1.24*	1.19	1.17–1.21	53.76	0.37	1.23*	1.18	1.16–1.20	19.14	0.23	1.28*	1.23	1.19–1.26
Small metro counties	38.72	0.31	1.30*	1.22	1.20–1.24	55.26	0.51	1.26*	1.18	1.15–1.20	21.21	0.33	1.42*	1.33	1.28–1.37
Urban non-metro counties	55.91	0.31	1.88*	1.66	1.63–1.68	79.01	0.52	1.80*	1.58	1.55–1.61	30.76	0.34	2.06*	1.82	1.76–1.87
Rural counties	80.00	1.17	2.69*	2.29	2.22–2.36	109.28	1.88	2.49*	2.11	2.04–2.19	47.36	1.31	3.17*	2.71	2.55–2.87
HIV/AIDS mortality															
Socioeconomic deprivation index															
Socioeconomic decile 1	0.83	0.05	4.15*	8.75	6.66–11.51	0.80	0.06	2.96*	6.34	4.53–8.88	0.86	0.07	7.82*	14.87	9.08–24.34
Socioeconomic decile 2	0.71	0.05	3.55*	8.00	6.02–10.64	0.55	0.06	2.04*	4.67	3.24–6.74	0.88	0.08	8.00*	16.19	9.82–26.69
Socioeconomic decile 3	0.45	0.03	2.25*	3.11	2.35–4.12	0.55	0.05	2.04*	2.76	1.97–3.87	0.35	0.04	3.18*	4.07	2.43–6.80
Socioeconomic deciles 4–7	0.47	0.02	2.35*	3.51	2.71–4.54	0.49	0.03	1.81*	2.71	1.99–3.69	0.45	0.02	4.09*	5.56	3.46–8.96
Socioeconomic decile 8	0.20	0.02	1.00	1.52	1.08–2.12	0.19	0.03	0.70	1.06	0.69–1.65	0.21	0.03	1.91*	2.66	1.52–4.66
Socioeconomic decile 9	0.30	0.03	1.50*	1.79	1.31–2.43	0.38	0.05	1.41*	1.66	1.14–2.40	0.21	0.03	1.91*	2.16	1.23–3.78
Socioeconomic decile 10	0.20	0.02	1.00	1.00	Reference	0.27	0.04	1.00	1.00	Reference	0.11	0.03	1.00	1.00	Reference
Rural–urban continuum category															
Large metro counties	0.61	0.02	2.54*	5.57	3.28–9.48	0.67	0.03	2.09*	4.06	2.16–7.63	0.55	0.02	3.93*	9.30	3.46–24.96
Medium metro counties	0.33	0.02	1.38*	2.49	1.45–4.28	0.29	0.03	0.91*	1.55	0.81–2.98	0.37	0.03	2.64*	4.85	1.79–13.15
Small metro counties	0.22	0.02	0.92	1.41	0.80–2.48	0.19	0.03	0.59	0.90	0.45–1.81	0.24	0.03	1.71*	2.66	0.96–7.40
Urban non-metro counties	0.29	0.02	1.21	1.40	0.81–2.42	0.27	0.03	0.84	0.97	0.50–1.88	0.31	0.03	2.21*	2.48	0.91–6.76
Rural counties	0.24	0.06	1.00	1.00	Reference	0.32	0.10	1.00	1.00	Reference	0.14	0.07	1.00	1.00	Reference

*$P<0.05$. Decile 1 of the socioeconomic deprivation index represents the most deprived group and decile 10 the least deprived group. For computing relative risks, the tenth socioeconomic decile was the reference category; large metro counties were the reference group for suicide and unintentional jury mortality, whereas rural counties were the reference group for homicide and HIV/AIDS mortality

US youth. The deprivation index is a summary representation of the living standards and socioeconomic conditions in US counties and has been shown to capture both absolute and distributive aspects of neighborhood and community socioeconomic disadvantage.[15–17] The deprivation index has been used previously to analyze population-based health disparities over time in all-cause, cardiovascular, and cancer mortality, infant and child mortality, and life expectancy in the USA.[15–18,22,23] As shown here, socioeconomic deprivation and urbanization are major determinants of youth mortality at the population level. As such, the deprivation index and the rural–urban continuum variable can serve as important surveillance tools for monitoring health disparities among youth.

Although international comparisons have been made previously,[24–26] our study provides the latest and one of the most comprehensive cross-national comparisons of youth mortality in the industrialized world. Our analysis shows that the US ranks poorly in overall youth mortality and youth homicide rates. Economic inequality has been shown to be a major predictor of cross-national variations in youth homicide rates, independent of per capita GDP or income levels.[27] The powerful impact of deprivation and to a lesser extent of urbanization on US youth mortality can be illustrated by discussing the excess mortality or population-attributable-risk analysis. Based on our analysis (not shown here for the sake of brevity), if all youths had experienced similar mortality risks as those living in the most affluent areas of the USA, there would have been 85,000 fewer deaths among youths during the period 1999–2007, including prevention of 28,300 homicides, 7,800 suicides, 40,000 unintentional injury deaths, and 940 HIV/AIDS deaths. Moreover, more than 26,000 homicides would have been averted during 1999–2007 if all youths experienced the homicide risk of those in rural areas. Nearly 27,000 unintentional injury deaths and 4,300 suicides would have been prevented during 1999–2007 if all youths experienced the injury or suicide risk of those in large metropolitan areas; these statistics reflect the excess burden of injury and suicide risk among rural youth.

The strong link between deprivation and youth homicide shown in our study confirms similar findings for the overall homicide rates which also vary greatly in relation to deprivation levels.[15–17] The substantial impact of urbanization on youth homicides underscores the significance of youth homicide as a major public health problem in large urban areas of the country and is consistent with a similar urbanization pattern seen in the homicide rate for the total population.[28] Our finding regarding increased suicide risks among young males and females in rural areas is in keeping with a previous study that showed similarly elevated risks of suicide among rural youth in both 1990–1994 and 1995–1997.[9] The finding about higher suicide rates in rural areas is compounded by the fact that rural populations have much lower access to mental health services than urban populations. The ARF data indicate that 79 % of non-metropolitan counties in 2007 were underserved for mental health services compared with 39 % of the metropolitan counties.[14]

HIV/AIDS mortality has declined sharply from its peak epidemic years of the early 1990s when it was the sixth leading cause of death among youth.[2] Despite the steep decline in mortality, HIV/AIDS continues to be the sixth and seventh leading cause of death among black and Hispanic youth, and socioeconomic inequalities remain very marked. Disparities in HIV/AIDS mortality most likely reflect inequalities in HIV incidence, access to antiretroviral therapy (ART) treatment, and associated patient survival.[29,30]

This study has some limitations. Area-based socioeconomic and rural–urban disparities in youth mortality documented here should not be considered as proxies

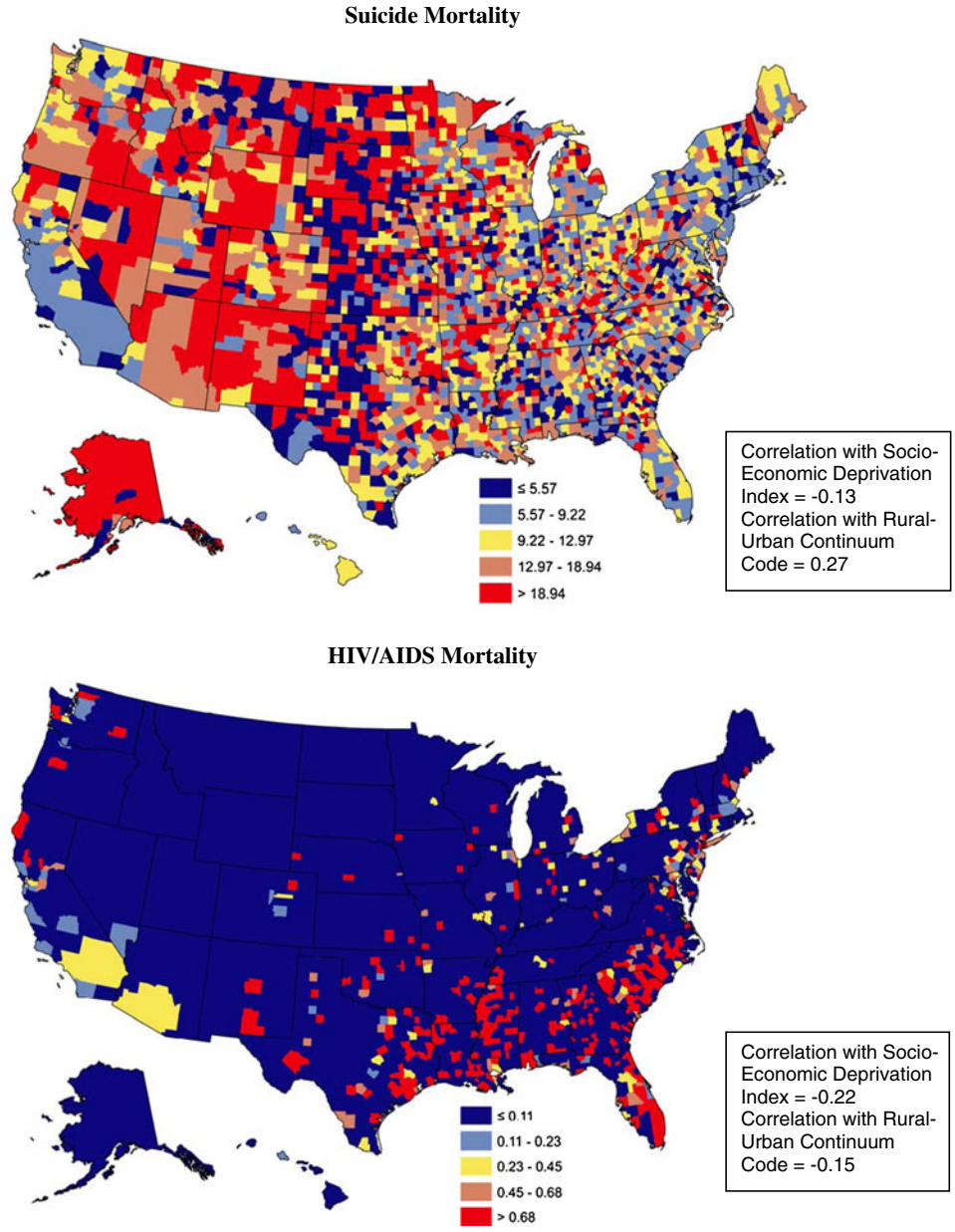

FIGURE 4. Suicide and HIV/AIDS mortality rates per 100,000 population, US youth aged 15–24 years, 1999–2007 (3,141 counties).

for differentials at the individual level. Such consideration may lead to the ecological fallacy.[15,16,18,23] In our study, county-level variations in cause-specific youth mortality rates were modeled as a function of two population-based ecologic variables, the deprivation index and rural–urban continuum. Although area-based socioeconomic patterns in youth mortality shown are generally consistent with those at the individual level, the area-level effects shown here may be smaller in magnitude than individual-level SES effects partly because of the compositional heterogeneity of the counties examined.[1,23]

The 1999–2007 youth mortality rates for almost all racial/ethnic, socioeconomic, and rural–urban groups shown here fall short of the Healthy People 2010 target of 40 deaths per 100,000 population.[31] Indeed, the national youth mortality rate is currently twice the rate set for the 2010 objective. The extent of social inequalities in youth mortality within the USA, coupled with the relatively unfavorable international ranking of the USA in the level of mortality, indicates the magnitude of health and social problems affecting American youth.

Homicide and suicide have become increasingly more prominent causes of death among American youth as a result of generally declining MVA mortality rates and small but significant increases in homicide and suicide rates during the past four decades.[2] Geographic differences in such factors as motor vehicle safety improvements, seat belt use, efforts to reduce drinking and driving, speed limits and enforcement, and availability of statewide trauma systems may partly account for area-based socioeconomic and rural–urban disparities in MVA mortality.[2,32] Lack of social support, low levels of familial attachment and social integration, living alone, drug and alcohol abuse, mental health problems, interpersonal conflicts, marital disruption, joblessness, and low socioeconomic status have been associated with increased risk of suicide and homicide victimization at the individual level.[2,9,33] Several aspects of the broader social environment (e.g., our deprivation index and urbanization variable) such as high unemployment rates, job losses, lack of economic opportunity, income inequality, poor housing, and geographic and social isolation, may be related to area variation in youth suicide and homicide rates.[2,9,17] Violence and injury prevention programs for youth should, therefore, include policies that are aimed at improving the broader socioeconomic conditions and social integration indicators.[2]

Homicide, suicide, and unintentional injuries remain major threats to health and well-being of American youth in terms of years of potential life lost, and they disproportionately affect their chances of survival into productive, working ages and beyond.[2] Given the considerable disparities in mortality shown here, sustained efforts are needed to reduce racial/ethnic, socioeconomic, and rural–urban disparities in homicide, suicide, and unintentional-injury mortality among American youth.

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