

WHY ARE DEATH RATES RISING AMONG WHITES IN MISSOURI?

The Role of Stress-Related Conditions

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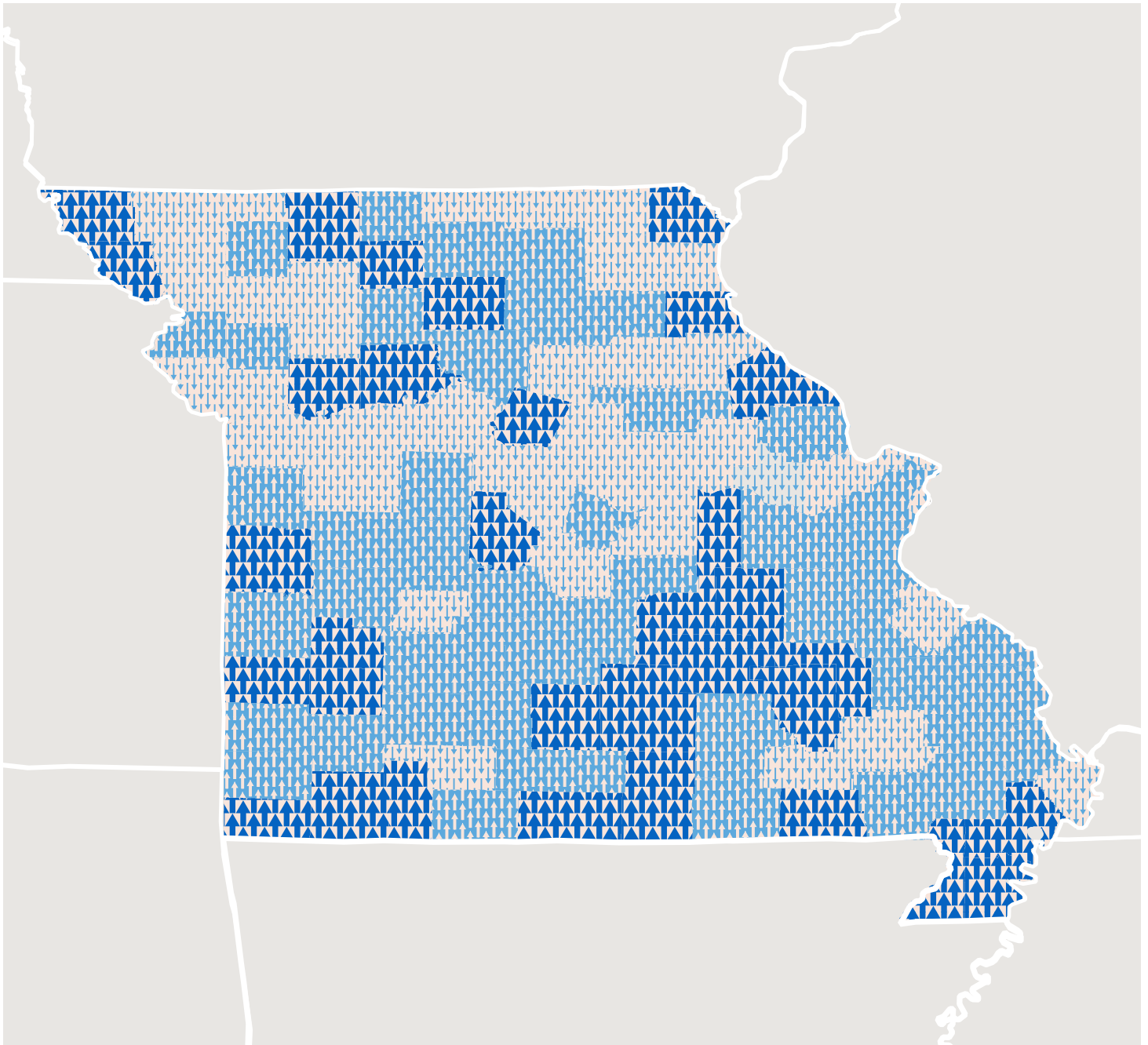
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INTRODUCTION

We undertook a detailed examination of state vital statistics from 1995 to 2014 and compared results across the state's 114 counties and the city of St. Louis. The study was funded by the Missouri Foundation for Health and involved a partnership between the Center on Society and Health at Virginia Commonwealth University and the Graduate School of Public Health at the University of Pittsburgh. Our topline findings are presented in an accompanying issue brief. This report provides documentation of the methods used in the study and greater detail about our results, along with data tables and figures, which could not be included in the issue brief.

METHODS

Deaths in Missouri were examined in aggregate (all-cause mortality) and for specific causes from 1995 to 2014. Death data for Missouri were obtained from the National Center for Health Statistics (NCHS) after approval by the National Association for Public Health Statistics and Information Systems. Individual-level death data, including county of residence, were abstracted from the Mortality Multiple Cause Micro-data Files. Rates or counts with fewer than 10 deaths were suppressed per NCHS regulations. Population counts for calculating mortality rates were obtained from the National Cancer Institute's Surveillance, Epidemiology, and End Results Program. The study was exempted by the institutional review board of Virginia Commonwealth University.

Death counts were aggregated into 5-year periods (1995-1999, 2000-2004, 2005-2009, and 2010-2014) to increase stability and reduce suppression. Mortality rates were stratified by age, sex, race, and ethnicity. Sample size considerations required the population to be classified into five, broad racial-ethnic groups: Hispanics/Latinos and non-Hispanic whites, non-Hispanic blacks, non-Hispanic Asians and Pacific Islanders, and non-Hispanic American Indians and Alaskan Natives. For simplicity, this report uses "whites" as a shorthand for NH whites.

Causes of death were coded to the International Classification of Diseases (ICD) revision in effect at the time of death. Causes of death were grouped into 116 categories in 11 broad domains (Table 1).

Table 1.
HIERARCHICAL STRUCTURE FOR ANALYSIS OF CAUSES OF DEATH, BY DOMAIN AND PROJECT CODES

CAUSE OF DEATH	PROJECT CODES (N = 111)	ICD-10 CODES
ALL CAUSES	001	A00-Z99
Domain 1. Infectious and parasitic diseases	002	A00-B99
Tuberculosis	003	A16-A19
Septicemia	004	A40-A41
Viral disease	005	A80-B34
Viral hepatitis	006	B15-B19
HIV disease	007	B20-B24
Domain 2. Cancer	008	C00-C97, D00-D48
Cancer of oral cavity and pharynx	009	C00-C14.8
Cancer of digestive organs	010	C15-C26, C48
Cancer of esophagus	011	C15
Cancer of stomach	012	C16
Cancer of other and ill-defined digestive	013	C17, C21, C23, C24, C26
Cancer of colon and rectum	014	C18-C20, C26.0
Cancer of liver and intrahepatic bile ducts	015	C22
Cancer of pancreas	016	C25
Cancer of the respiratory system	017	C30-C39
Cancer of larynx	018	C32
Cancer of lung and bronchus	019	C34
Cancer, melanoma of skin	020	C43
Cancer of breast	021	C50
Cancer of cervix uteri	022	C53
Cancer of corpus/uterus, NOS	023	C54-C55
Cancer of ovary	024	C56
Cancer of prostate	025	C61
Cancer of the testis	026	C62
Cancer of kidney and renal pelvis	027	C64-C65
Cancer of urinary bladder	028	C67
Cancer of brain/other nervous system	029	C70-C72
Cancer of thyroid	030	C73
Cancer, Hodgkin lymphoma	031	C81
Cancer, non-Hodgkin lymphoma	032	C82-C85
Cancer, myeloma	033	C88.7-C88.9, C90.0, C90.2
Cancer, leukemia	034	C90.1, C91-C95
In situ, benign and uncertain neoplasms	035	D00-D48
Domain 3. Diseases of the endocrine system	038	E00-E88
Diabetes mellitus	039	E10-E14
Nutritional deficiencies	040	E40-E64
Malnutrition	041	E40-E46
Obesity	042	E65-E68
Metabolic disorders	043	E70-E88
Domain 4. Diseases of the nervous system	045	G00-G98
Meningitis	046	G00, G03
Parkinson's disease	047	G20-G21
Alzheimer's disease	048	G30
Multiple sclerosis	049	G35
Epilepsy	050	G40-G41

CAUSE OF DEATH	PROJECT CODES (N = 111)	ICD-10 CODES
Domain 5. Diseases of the circulatory system	114	I00-I99
Heart disease	052	I00-I09, I11, I13, I20-I51
Rheumatic fever (acute) and chronic rheumatic heart diseases	053	I00-I09
Coronary heart disease	054	I11, I20-I25, I51.6
Hypertensive heart disease	055	I11
Ischemic heart diseases	056	I20-I25
Acute myocardial infarction	057	I21-I22
Atherosclerotic cardiovascular disease	058	I25.0
Hypertensive heart and renal disease	059	I13
Heart failure	060	I50
Hypertension (essential/primary) and hypertensive renal disease	061	I10, I12
Cerebrovascular diseases	062	I60-I69
Atherosclerosis	063	I70
Phlebitis, thrombophlebitis, venous embolism and thrombosis	064	I80-I82
Domain 6. Diseases of the respiratory system	065	J00-J98
Influenza and pneumonia	066	J10-J18
Influenza	067	J10-J11
Pneumonia	068	J12-J18
Chronic lower respiratory diseases	069	J40-J47
Bronchitis, chronic and unspecified	070	J40-J42
Emphysema	071	J43
Asthma	072	J45-J46
Pneumoconiosis	073	J60-J66
Pneumonitis due to solids and liquids	074	J69
Domain 7. Diseases of the digestive system	075	K00-K92
Peptic ulcer	076	K25-K28
Liver disease, chronic and cirrhosis	077	K70, K73-K74
Liver, alcoholic liver disease	078	K70
Cholelithiasis and other disorders of gallbladder	079	K80-K82
Pancreas and biliary tract disorders	080	K83-K86
Domain 8. Genitourinary system	084	N00-N98
Nephritis, nephrotic syndrome and nephrosis	085	N00-N07, N17-N19, N25-N27
Renal failure	086	N17-N19
Domain 9. Congenital malformations, deformations, chromosomal abnormalities	089	Q00-Q99
Domain 10. External cause of death, injury and accidents	091	U01-U03, V01-Y89
Homicide (assault)	095	U01-U02, X85-Y09, Y87.1
Homicide (assault), by discharge of firearm	096	U01.4, X93-X95
Suicide (intentional self-harm)	097	U03, X60-X84, Y87.0
Suicide (intentional self-harm), not firearm, other or unknown	098	U03, X60-X71, X75-X84, Y87.0
Suicide (intentional self-harm), by firearm	099	X72-X74
Accidents	100	V01-X59, Y85-Y86
Accidents, transport	101	V01-V99, Y85
Accidents, other transport, not motor vehicles	102	V01, V05-V06, V09.1, V09.3-V09.9, V10-V11, V15-V18, V19.3, V19.8-V19.9, V80.0-V80.2, V80.6-V80.9, V81.2-V81.9, V82.2-V82.9, V87.9, V88.9, V89.1, V89.3, V89.9, V90-V99, Y85

CAUSE OF DEATH	PROJECT CODES (N = 111)	ICD-10 CODES
Accidents, motor vehicle	103	V02-V04, V09.0, V09.2, V12-V14, V19.0-V19.2, V19.4-V19.6, V20-V79, V80.3-V80.5, V81.0-V81.1, V82.0-V82.1, V83-V86, V87.0-V87.8, V88.0-V88.8, V89.0, V89.2
Accidents, nontransport	104	W00-X59, Y86
Accidents, nontransport excluding poisoning	105	W00-X39, X50-X59, Y86
Falls	106	W00-W19
Accidental discharge of firearms	107	W32-W34
Drowning and submersion (accidental)	108	V90, V92, W65-W74
Fire, smoke, and flames (accidental)	109	X00-X09
Accidental poisoning and exposure to noxious substances	110	X40-X49
Accidental drug poisoning	111	X40-X44
Accidental alcohol poisoning	112	X45
Complications of medical and surgical care	113	Y40-Y84, Y88
Domain 11. Other causes of death		
Diseases of the blood and blood forming organs	036	D50-D89
Mental and behavioral disorders	044	F01-F99
Skin and subcutaneous tissue	081	L00-L98
Diseases of the musculoskeletal system & connective tissue	082	M00-M99
Rheumatoid arthritis and related inflammatory polyarthropathies	083	M05-M08
Pregnancy, childbirth, and the puerperium	087	O00-O99
Perinatal conditions	088	P00-P96
Symptoms, signs not otherwise classified	090	R00-R99
Diseases of the eye, adnexa, ear and mastoid	115	H00-H57, H60-H93

Deaths from 1995-1998 and 1999-2014 were coded to ICD-9 and ICD-10, respectively (Table 2). Because the transition from ICD-9 to ICD-10 in 1999 could potentially introduce artifactual changes in cause-specific rates and because some mortality patterns changed distinctly after 2000-2004, the percentage increase in mortality rates was measured from two baseline time periods: 1995-1999 and 2000-2004. Mortality data are not shown for 1995-1999 if the specific cause of death that did not have corresponding codes in the 9th and 10th revisions; mortality rates for these causes of death are shown only from 2000-2004 to 2010-2014.

PROJECT CODE	CAUSE OF DEATH	ICD-10 CODE	ICD-9 CODE
1	All causes of death	A00-Z99	000-799, E800-E999
2	Infectious and parasitic diseases	A00-B99	000-139
3	Tuberculosis	A16-A19	010-018
4	Septicemia	A40-A41	038
5	Viral disease	A80-B34	042-079
6	Viral hepatitis	B15-B19	070
7	Human immunodeficiency virus (HIV) disease	B20-B24	042-044
8	Cancer	C00-C97	140-208
9	Cancer of oral cavity and pharynx	C00-C14.8	140-149

PROJECT CODE	CAUSE OF DEATH	ICD-10 CODE	ICD-9 CODE
10	Cancer of digestive organs	C15-C26, C48	150-159
11	Cancer of esophagus	C15	150
12	Cancer of stomach	C16	151
13	Cancer of other and ill-defined digestive	C17, C21, C23, C24, C26	152, 154.2, 154.3, 154.8, 156, 159.1, 159.8, 159.9
14	Cancer of colon and rectum	C18-C20, C26.0	153.0-154.1, 159.0
15	Cancer of liver and intrahepatic bile ducts	C22	155
16	Cancer of pancreas	C25	157
17	Cancer of the respiratory system	C30-C39	160-165
18	Cancer of larynx	C32	161
19	Cancer of lung and bronchus	C34	162.2-162.9
20	Cancer, melanoma of skin	C43	172
21	Cancer of breast	C50	174-175
22	Cancer of cervix uteri	C53	180
23	Cancer of corpus/uterus, NOS	C54-C55	179, 182.0-182.8
24	Cancer of ovary	C56	183.0
25	Cancer of prostate	C61	185
26	Cancer of the testis	C62	186
27	Cancer of kidney and renal pelvis	C64-C65	189.0, 189.1
28	Cancer of urinary bladder	C67	188
29	Cancer of brain/other nervous system	C70-C72	191-192
30	Cancer of thyroid	C73	193
31	Cancer, Hodgkin lymphoma	C81	201
32	Cancer, non-Hodgkin lymphoma	C82-C85	200.0-200.8, 202.0-202.2, 202.8-202.9
33	Cancer, myeloma	C88.7-C88.9, C90.0, C90.2	203.0, 203.2-203.8
34	Cancer, leukemia	C90.1, C91-C95	202.4, 203.1, 204-208
35	In situ, benign and uncertain neoplasms	D00-D48	210-239
36	Diseases of the blood and blood forming organs	D50-D89	280-289
37	Drug-induced deaths	D52.1, D59.0, D59.2, D61.1, D64.2, E06.4, E16.0, E23.1, E24.2, E27.3, E66.1, F11.0-F11.5, F11.7-F12.5, F12.7-F13.5, F13.7-F14.5, F14.7-F15.5, F15.7-F16.5, F16.7-F17.0, F17.3-F17.5, F17.7-F18.5, F18.7-F19.5, F19.7-F19.9, G21.1, G24.0, G25.1, G25.4, G25.6, G44.4, G62.0, G72.0, I95.2, J70.2-J70.4, L10.5, L27.0-L27.1, M10.2, M32.0, M80.4, M81.4, M83.5, M87.1, R78.1-R78.5, U01.6, X40-X44, X60-X64, X85, Y10-Y14	292, 304, 305.2-305.9, E850-E858, E950.0-E950.5, E962.0, E980.0-E980.5
38	Diseases of the endocrine system	E00-E88	240-279
39	Diabetes mellitus	E10-E14	250
40	Nutritional deficiencies	E40-E64	260-269
41	Malnutrition	E40-E46	260-263
42	Obesity	E65-E68	278
43	Metabolic disorders	E70-E88	270-277
44	Mental and behavioral disorders	F01-F99	290-319
45	Diseases of the nervous system	G00-G98	320-359
46	Meningitis	G00, G03	320-322
47	Parkinson's disease	G20-G21	332
48	Alzheimer's disease	G30	331.0
49	Multiple sclerosis	G35	340
50	Epilepsy	G40-G41	345
51	Cardiovascular diseases (major)	I00-I78	390-448

PROJECT CODE	CAUSE OF DEATH	ICD-10 CODE	ICD-9 CODE
52	Heart disease	I00-I09, I11, I13, I20-I51	390-398, 402, 404-429
53	Rheumatic fever (acute) and chronic rheumatic heart diseases	I00-I09	390-398
54	Coronary heart disease	I11, I20-I25, I51.6	402, 410-414, 429.2
55	Hypertensive heart disease	I11	402
56	Ischemic heart diseases	I20-I25	410-414
57	Acute myocardial infarction	I21-I22	410
58	Atherosclerotic cardiovascular disease	I25.0	429.2
59	Hypertensive heart and renal disease	I13	404
60	Heart failure	I50	428
61	Hypertension (essential/primary) and hypertensive renal disease	I10, I12	401, 403
62	Cerebrovascular diseases	I60-I69	430-438
63	Atherosclerosis	I70	440
64	Phlebitis, thrombophlebitis, venous embolism and thrombosis	I80-I82	451-453
65	Diseases of the respiratory system	J00-J98	460-519
66	Influenza and pneumonia	J10-J18	480-487
67	Influenza	J10-J11	487
68	Pneumonia	J12-J18	480-486
69	Chronic lower respiratory diseases	J40-J47	490-496
70	Bronchitis, chronic and unspecified	J40-J42	490-491
71	Emphysema	J43	492
72	Asthma	J45-J46	493
73	Pneumoconiosis	J60-J66	500-505
74	Pneumonitis due to solids and liquids	J69	507
75	Diseases of the digestive system	K00-K92	520-579
76	Peptic ulcer	K25-K28	531-534
77	Liver disease, chronic and cirrhosis	K70, K73-K74	571
78	Liver, alcoholic liver disease	K70	571.0-571.3
79	Cholelithiasis and other disorders of gallbladder	K80-K82	574-575
80	Pancreas and biliary tract disorders	K83-K86	576-577
81	Skin and subcutaneous tissue	L00-L98	680-709
82	Diseases of the musculoskeletal system & connective tissue	M00-M99	710-739
83	Rheumatoid arthritis and related inflammatory polyarthropathies	M05-M08	714
84	Genitourinary system	N00-N98	580-629
85	Nephritis, nephrotic syndrome and nephrosis	N00-N07, N17-N19, N25-N27	580-589
86	Renal failure	N17-N19	584-586
87	Pregnancy, childbirth, and the puerperium	O00-O99	630-676
88	Perinatal conditions	P00-P96	760-779
89	Congenital malformations, deformations, chromosomal abnormalities	Q00-Q99	740-759
90	Symptoms, signs not otherwise classified	R00-R99	780-799
91	External cause of death, injury and accidents	U01-U03, V01-Y89	E800-E999
92	Firearm related injuries (accidental, suicide, homicide, undetermined, legal interv.)	U01.4, W32-W34, X72-X74, X93-X95, Y22-Y24, Y35.0	E922, E955.0-E955.4, E965.0-E965.4, E970, E985.0-E985.4
93	Poisoning (accidental, suicide, homicide, undetermined, legal interv.)	U01.6, U01.7, X40-X49, X60-X69, X85-X90, Y10-Y19, Y35.2	E850-E869, E950-E952, E962, E972, E980-E982
94	Suffocation and strangulation (accidental, suicide, homicide, undetermined)	W75-W84, X70, X91, Y20	E911-E913, E953, E963, E983
95	Homicide (assault)	U01-U02, X85-Y09, Y87.1	E960-E969
96	Homicide (assault), by discharge of firearm	U01.4, X93-X95	E965.0-E965.4
97	Suicide (intentional self-harm)	U03, X60-X84, Y87.0	E950-E959
98	Suicide (intentional self-harm), not firearm, other or unknown	U03, X60-X71, X75-X84, Y87.0	E950-E954, E955.5-E959.9
99	Suicide (intentional self-harm), by firearm	X72-X74	E955.0-E955.4

PROJECT CODE	CAUSE OF DEATH	ICD-10 CODE	ICD-9 CODE
100	Accidents	V01-X59, Y85-Y86	E800-E869, E880-E929
101	Accidents, transport	V01-V99, Y85	E800-E848, E929.0, E929.1
102	Accidents, other transport, not motor vehicles	V01, V05-V06, V09.1, V09.3-V09.9, V10-V11, V15-V18, V19.3, V19.8-V19.9, V80.0-V80.2, V80.6-V80.9, V81.2-V81.9, V82.2-V82.9, V87.9, V88.9, V89.1, V89.3, V89.9, V90-V99, Y85	E800-E807, E820-E848, E929.0, E929.1
103	Accidents, motor vehicle	V02-V04, V09.0, V09.2, V12-V14, V19.0-V19.2, V19.4-V19.6, V20-V79, V80.3-V80.5, V81.0-V81.1, V82.0-V82.1, V83-V86, V87.0-V87.8, V88.0-V88.8, V89.0, V89.2	E810-E819
104	Accidents, nontransport	W00-X59, Y86	E850-E869, E880-E928, E929.2-E929.9
105	Accidents, nontransport excluding poisoning	W00-X39, X50-X59, Y86	E880-E924.0, E924.8-E928, E929.2-E929.9
106	Falls	W00-W19	E880-E886, E888
107	Accidental discharge of firearms	W32-W34	E922
108	Drowning and submersion (accidental)	V90, V92, W65-W74	E830, E832, E910
109	Fire, smoke, and flames (accidental)	X00-X09	E890-E899
110	Accidental poisoning and exposure to noxious substances	X40-X49	E850-E869, E924.1
111	Accidental drug poisoning	X40-X44	E850-E858
112	Accidental alcohol poisoning	X45	E860
113	Complications of medical and surgical care	Y40-Y84, Y88	E870-E879, E930-E949
114	Diseases of the circulatory system	I00-I99	390-459
115	H codes	H00-H57, H60-H93	360-389
116	R and Y codes	R00-R99, Y10-Y39, Y89	780-799, E970-E999

Although the analysis focused on age-specific mortality rates, age adjustment was performed to account for changes in age distributions within the age groups. Weights calculated from the 2000 US standard million population were applied to age-specific rates and summed across age-groups to produce the final age-adjusted rates. Trends in death rates reported in the issue brief generally refer to age-adjusted rates; crude rates are reported in selected tables to provide the reader with complete information on actual death rates. The statistical significance of differences in mortality rates was determined using the standard error of the difference (for crude rates) and by checking for overlap between 95% confidence intervals, which were computed using Fay and Feuer's method using the gamma distribution (for age-adjusted rates). Calculations were performed in SAS (version 9.4, Cary, NC).

The study focused on identifying causes of death responsible for shifting death rates in the population. This was accomplished by systematically examining and reporting all-cause mortality trends by race and ethnicity and then conducting a more detailed analysis of mortality trends among non-Hispanic whites. Using an interactive data tool developed for this project, aggregate deaths were combined across age groups to pinpoint the span in age groups that experienced a distinct trend of increasing mortality rates. As reported below, we identified whites ages 25-59 years as the group of interest in Missouri and found 106 counties in which this age group experienced an increased mortality rate.

The study then focused on identifying the specific causes of death responsible for this trend in the 106 affected counties in which crude mortality rates had increased. This involved a systematic examination of mortality trends at each level of the hierarchical classification of deaths (Table 1), from mortality trends in the 10 broadest categories of causes of death, to those in the 116 causes of death, and those at specific 3-digit and 4-digit ICD code levels. We focused on causes of death that produced a statistically significant increase in age-adjusted mortality rates.

Excess and averted deaths were calculated using the following procedure: The expected number of deaths for each time period (assuming no mortality increase) was computed by applying the prior time period's crude mortality rate to the subsequent time period's population. Specifically, crude mortality rates for 1995-1999 were applied to the population of 2000-2004, 2000-2004 mortality rates to the 2005-2009 population, and 2005-2009 rates to the 2010-2014 population. Actual deaths were subtracted from the expected deaths to determine the number of averted deaths (decrease in cause-specific mortality) or excess (increase in cause-specific mortality) for each time period. The number of averted/excess deaths was summed over the three time periods to arrive at a total number of averted/excess deaths by cause.

Finally, we grouped the counties based on magnitude of change in age-adjusted all-cause mortality: those in which mortality decreased, those with a modest increase in mortality (0-50 deaths per 100,000), and those with a large increase (more than 50 deaths per 100,000). We used data from the U.S. Census Bureau to compare these counties in terms of geographic and demographic characteristics, socioeconomic conditions, the physical environment, housing, transportation, and access to health care (Table 3).

Table 3. PLACE-BASED INDICATORS EXAMINED IN MISSOURI COUNTIES		
PLACE-BASED INDICATOR	DEFINITION	DATA SOURCE
Geographic Characteristics		
Rural (%)	Percentage of the county population living in rural areas	U.S. Census, 2010 Census Urban and Rural Classification
Urban (%)	Percentage of the county population living in urban areas	U.S. Census, 2010 Census Urban and Rural Classification
Demographic Characteristics		
Single parent households (%)	Percentage of children who live in single-parent households	2016 County Health Rankings
Diversity Index	Probability that two individuals chosen at random would be of different races or ethnicities	PolicyMap, 2010-2014
Foreign born population (%)	Percentage of the population who is foreign-born	U.S. Census, ACS 2014 5-year estimates, Table B05012
Socioeconomic Conditions		
Limited English proficiency (%)	Percentage of households where no one age 14 and over speaks English only or speaks English "very well"	2016 County Health Rankings

PLACE-BASED INDICATOR	DEFINITION	DATA SOURCE
Bachelor's degree or more education (%)	Percentage of persons 25 years or older with a Bachelor's degree or higher	U.S. Census, ACS 2014 5-year estimates, Table S1505
Unemployment (%)	Percentage of civilian labor force (ages 16 and older) that is unemployed but seeking work	2016 County Health Rankings
Median household income (\$)	Median annual household income	2016 County Health Rankings
Poverty (%)	Percentage of population living below poverty level	U.S. Census, ACS 2015 5-year estimates, Table S1701
Poverty (adult only, %)	Percentage of population ages 18-64 years living below poverty level	U.S. Census, ACS 2015 5-year estimates, Table S1701
Child poverty (%)	Percentage of children (under age 18 years) living in poverty	2016 County Health Rankings
Gini Index	Statistical dispersion measure (zero to 1.0) representing the distribution of income	U.S. Census, ACS 2014 5-year estimates, Table B19083
Physical Environment		
Close proximity to highways (%)	Percent of population living within 150 meters of a highway	CDC Environmental Public Health Tracking Network, 2010
Ozone days (per year)	Number of ozone days per year above regulatory standard	CDC Environmental Public Health Tracking Network, 2012
Access to parks (%)	Percentage of population living within a half mile of a park	CDC Environmental Public Health Tracking Network, 2010
Low food access (%)	Percentage of population living more than 1 mile from a grocery store in an urban area or more than 10 miles in a rural area	2015 USDA ERS Food Environment Atlas
Violent crime rate (per 100,000)	Number of reported violent crime offenses per 100,000 population	2016 County Health Rankings
Housing		
Overcrowding (%)	Percentage of households with more than one occupant per room	U.S. Census, ACS 2014 5-year estimates, Table DP04
Cost burden (homeowners, %)	Percentage of owner-occupied households paying more than 30% of income on housing	U.S. Census, ACS 2014 5-year estimates, Table B25093
Cost burden (renters, %)	Percentage of renter-occupied households paying more than 30% of income on housing	U.S. Census, ACS 2014 5-year estimates, Table B25070
Severe housing disrepair (%)	Percentage of households with at least 1 of 4 housing problems: overcrowding, high housing costs, or lack of kitchen or plumbing facilities	2016 County Health Rankings
Housing built before 1950 (%)	Proportion of housing units built 1950 or earlier	U.S. Census, ACS 2014 5-year estimates, Table B25034
Transportation		
No vehicle access (%)	Percentage of workers age 16 years and over in households without a vehicle available	U.S. Census, ACS 2014 5-year estimates, Table B08141
Commuting to work by motor vehicle (%)	Percentage who commute by car, truck, van, taxi, motorcycle, or other means	U.S. Census, ACS 2014 5-year estimates, Table S0801
Commuting to work by public transit (%)	Percentage of workers age 16 years and over who commute to work by bus, train, or subway	U.S. Census, ACS 2014 5-year estimates, Table S0801
Commuting to work by walking/cycling (%)	Percentage of workers age 16 years and over who commute to work by walking or cycling	U.S. Census, ACS 2014 5-year estimates, Table S0801
Access to Health Care		
Primary care physician ratio	Ratio of population to primary care physicians	2016 County Health Rankings
Mental health provider ratio	Ratio of population to mental health providers	2016 County Health Rankings
Dentist ratio	Ratio of population to dentists	2016 County Health Rankings
Uninsured (%)	Percentage of population without any health insurance	U.S. Census, ACS 2014 5-year estimates, Table S2701
Public insurance (%)	Percentage with public health insurance (e.g., Medicare, Medicaid)	U.S. Census, ACS 2014 5-year estimates, Table S2701
Private insurance (%)	Percent with private insurance	U.S. Census, ACS 2014 5-year estimates, Table S2701
ACS=American Community Survey, CDC=Centers for Disease Control and Prevention		

Finally, we examined temporal socioeconomic data to see how the three groups of counties fared over time in terms of median household income, poverty, and unemployment. We obtained data from the U.S. Census Bureau, using its Small Area Income and Poverty Estimates (SAIPE) Program for recent decades (1999 forward) and its Historical Income Tables to examine whether the patterns observed predate the observation period of this study.

RESULTS

We found that age-adjusted all-cause mortality decreased in Missouri between 1995-1999 and 2010-2014, but the decrease was more pronounced among people of color (Table 4). The mortality rate among non-Hispanic whites decreased by 12%, compared to more than 20% among non-Hispanic blacks, American Indian and Alaskan Natives, and Asians and Pacific Islanders and more than 50% among Hispanics.

Table 4.
ALL-CAUSE MORTALITY RATES (ALL AGES), BY RACE-ETHNICITY, MISSOURI, 1995-2014

RACE-ETHNICITY	1995-1999		2000-2004		2005-2009		2010-2014		RELATIVE CHANGE IN AGE-ADJUSTED MORTALITY RATE (%)	
	DEATHS (NO.)	AGE-ADJUSTED MORTALITY RATE	DEATHS (NO.)	AGE-ADJUSTED MORTALITY RATE	DEATHS (NO.)	AGE-ADJUSTED MORTALITY RATE	DEATHS (NO.)	AGE-ADJUSTED MORTALITY RATE	FROM 1995-99 TO 2010-14	FROM 2000-04 TO 2010-14
Non-Hispanic whites	242,781	913.2	243,784	881.9	243,413	833.6	250,639	800.8	-12.3%	-9.2%
Non-Hispanic blacks	27,996	1249.7	27,973	1173.4	27,543	1054.2	28,192	958.5	-23.3%	-18.3%
Non-Hispanic American Indians and Alaskan Natives	360	565.9	430	473.7	502	487.6	541	432.8	-23.5%	-8.6%
Non-Hispanic Asians and Pacific Islanders	605	563.9	768	448.0	884	371.9	1,369	418.2	-25.8%	-6.7%
Hispanics	1,580	840.2	2,035	713.3	1,902	491.8	2,123	395.4	-52.9%	-44.6%

Our statewide analysis of crude mortality rates among non-Hispanic whites of different ages revealed increases in all-cause crude mortality rates in all 5-year age bands between ages 25 and 59 years (rates decreased during these years for those under age 25 and older than age 60). The largest proportionate increases were observed among non-Hispanic whites ages 25-34 years and 40-59 years.

We then examined changes in crude rates by county and found 44 counties where crude rates increased among non-Hispanic whites ages 25-34 years, 107 counties

in which rates increased among those ages 35-59 years, and 106 counties in which rates increased among those ages 25-59 years (Table 5). This group of 106 counties were assembled as an “aggregate,” and their populations of whites ages 25-59 years served as the denominator for calculating mortality rates.

Table 5.
COUNTIES WITH AN INCREASE IN CRUDE MORTALITY RATES AMONG NON-HISPANIC WHITES
BETWEEN THE AGES OF 25 AND 59 YEARS, FROM 1995-1999 TO 2010-2014

AGES 25-34 YEARS (N=44)	AGES 35-59 YEARS (N=107)	AGES 25-59 YEARS (N=106)
Andrew County	Adair County	Adair County
Audrain County	Andrew County	Andrew County
Barry County	Atchison County	Atchison County
Buchanan County	Audrain County	Audrain County
Butler County	Barry County	Barry County
Callaway County	Barton County	Barton County
Cape Girardeau County	Bates County	Bates County
Carroll County	Benton County	Benton County
Cass County	Bollinger County	Bollinger County
Christian County	Boone County	Boone County
Clinton County	Buchanan County	Buchanan County
Cole County	Butler County	Butler County
Crawford County	Caldwell County	Callaway County
Dent County	Callaway County	Camden County
Douglas County	Camden County	Cape Girardeau County
Dunklin County	Cape Girardeau County	Carroll County
Franklin County	Carroll County	Carter County
Greene County	Cass County	Cass County
Henry County	Cedar County	Cedar County
Howell County	Chariton County	Chariton County
Jefferson Count	Clark County	Christian County
Laclede County	Clay County	Clark County
Lincoln County	Clinton County	Clay County
Livingston County	Cole County	Clinton County
Madison County	Cooper County	Cole County
McDonald County	Crawford County	Cooper County
New Madrid County	Dade County	Crawford County
Newton County	Dallas County	Dade County
Pemiscot County	Daviess County	Dallas County
Phelps County	DeKalb County	Daviess County
Platte County	Dent County	DeKalb County
Polk County	Douglas County	Dent County
Pulaski County	Dunklin County	Douglas County
Ray County	Franklin County	Dunklin County
St. Charles County	Gasconade County	Franklin County
St. Francois County	Gentry County	Gasconade County
St. Louis County	Greene County	Gentry County
Ste. Genevieve County	Grundy County	Greene County
Stoddard County	Harrison County	Grundy County
Stone County	Henry County	Harrison County
Taney County	Holt County	Henry County
Washington County	Howard County	Holt County

AGES 25-34 YEARS (N=44)	AGES 35-59 YEARS (N=107)	AGES 25-59 YEARS (N=106)
Webster County Wright County	Howell County Iron County Jackson County Jasper County Jefferson Count Johnson County Knox County Laclede County Lafayette County Lawrence County Lewis County Lincoln County Linn County Livingston County McDonald County Macon County Madison County Maries County Marion County Mercer County Miller County Mississippi County Moniteau County Montgomery County Morgan County New Madrid County Newton County Nodaway County Oregon County Ozark County Pemiscot County Perry County Pettis County Phelps County Pike County Platte County Polk County Pulaski County Putnam County Ralls County Randolph County Ray County Reynolds County Ripley County St. Charles County St. Clair County Ste. Genevieve County St. Francois County St. Louis County Saline County Scott County	Howard County Howell County Iron County Jackson County Jasper County Jefferson Count Johnson County Knox County Laclede County Lafayette County Lawrence County Lewis County Lincoln County Linn County Livingston County Macon County Madison County Maries County Marion County McDonald County Mercer County Miller County Moniteau County Montgomery County Morgan County New Madrid County Newton County Oregon County Ozark County Pemiscot County Perry County Pettis County Phelps County Pike County Platte County Polk County Pulaski County Putnam County Ralls County Randolph County Ray County Reynolds County Ripley County Saline County Scotland County Scott County Shannon County Shelby County St. Charles County St. Clair County St. Francois County

AGES 25-34 YEARS (N=44)	AGES 35-59 YEARS (N=107)	AGES 25-59 YEARS (N=106)
	Shannon County	St. Louis County
	Shelby County	Ste. Genevieve County
	Stoddard County	Stoddard County
	Stone County	Stone County
	Sullivan County	Sullivan County
	Taney County	Taney County
	Texas County	Texas County
	Vernon County	Vernon County
	Warren County	Warren County
	Washington County	Washington County
	Wayne County	Wayne County
	Webster County	Webster County
	Worth County	Wright County
	Wright County	

Table 6 reports crude and age-adjusted mortality rates for the 106 counties where mortality rates increased among non-Hispanic whites ages 25-59 years. The most significant increases observed between 1995-99 and 2010-14 occurred among young white adults (ages 25-34 years).

Table 6.
ALL-CAUSE MORTALITY RATES IN IMPACTED COUNTIES* AMONG NON-HISPANIC WHITES AGES 25-59, MISSOURI, 1995-2014

AGE GROUP	1995-1999		2000-2004		2005-2009		2010-2014		RELATIVE INCREASE IN AGE-ADJUSTED MORTALITY RATE (%)	
	DEATHS (NO.)	AGE-ADJUSTED MORTALITY RATE (CRUDE)	DEATHS (NO.)	AGE-ADJUSTED MORTALITY RATE (CRUDE)	DEATHS (NO.)	AGE-ADJUSTED MORTALITY RATE (CRUDE)	DEATHS (NO.)	AGE-ADJUSTED MORTALITY RATE (CRUDE)	FROM 1995-99 TO 2010-14 (CRUDE)	FROM 2000-04 TO 2010-14 (CRUDE)
Ages 25-34 years	4,102	116.4 (116.4)	3,639	109.2 (109.2)	4,139	121.9 (121.0)	4,572	127.1 (126.6)	9.3% (8.7%)	16.4% (15.9%)
Ages 35-59 years	27,996	1249.7	27,973	1173.4	27,543	1054.2	28,192	958.5	-23.3%	-18.3%
Ages 25-59 years	31,421	379.3 (376.0)	35,265	374.3 (387.6)	39,119	379.1 (413.0)	40,658	382.5	-23.5%	-8.6%
Non-Hispanic Asians and Pacific Islanders	35,523	305.3 (299.0)	38,904	299.7 (313.0)	43,258	306.7 (335.5)	45,230	310.6 (349.0)	1.7% (NS) (16.7)	3.6% (11.5)

NS = not statistically significant.

*See Table 5 for a list of the impacted counties in which crude mortality rates increased in this age group. The data reported here are based on the separate county aggregates for ages 25-34 years, 35-59 years, and 25-59 years, respectively.

Table 7 reports the changes in crude and age-adjusted all-cause mortality rates for all 114 counties in Missouri and the city of St. Louis. We identified 79 counties in which the age-adjusted mortality rates among whites increased between 1995-99 and 2010-14 in the target age group, including 33 counties where the increase exceeded 50 deaths per 100,000 persons. Counties that experienced an increase in mortality rates were largely rural. Mortality rates decreased in 36 counties and the city of St. Louis, most located in metropolitan areas and the Interstate 70 corridor between Kansas City and St. Louis (see map in Figure 2 of issue brief).

Table 7.
CHANGES IN ALL-CAUSE MORTALITY AMONG NON-HISPANIC WHITES AGES 25-59 YEARS, BY COUNTY
(AND THE CITY OF ST. LOUIS), MISSOURI

COUNTY	1995-1999		2010-2014		CHANGE IN AGE-ADJUSTED MORTALITY BETWEEN 1995-99 AND 2010-14	
	DEATHS	AGE-ADJUSTED MORTALITY RATE (CRUDE)	DEATHS	AGE-ADJUSTED MORTALITY RATE (CRUDE)	PROPORTIONAL CHANGE (%)	ABSOLUTE CHANGE (DEATHS PER 100,000)
LARGE INCREASES IN MORTALITY SINCE 1995-1999 (GREATER THAN 50 DEATHS PER 100,000) (N=33)						
Atchison County	40	262.5 (276.2)	48	327.3 (412.4)	24.7%	64.7
Barry County	251	329.0 (341.0)	361	406.6 (471.5)	23.6%	77.6
Barton County	59	226.2 (224.9)	93	311.4 (353.5)	37.7%	85.2
Bates County	120	337.5 (345.0)	164	390.4 (445.5)	15.7%	52.9
Carroll County	73	323.0 (334.0)	91	397.4 (464.7)	23.0%	74.4
Cedar County	95	305.2 (342.8)	125	388.7 (451.6)	27.4%	83.6
Clark County	54	302.4 (317.3)	64	363.9 (417.4)	20.3%	61.5
Crawford County	163	325.2 (330.8)	258	395.3 (464.5)	21.6%	70.1
Dade County	59	324.1 (351.9)	82	393.5 (499.5)	21.4%	69.4
Dent County	124	362.5 (386.0)	179	458.3 (526.7)	26.4%	95.8
Dunklin County	348	454.4 (473.2)	457	580.8 (664.8)	27.8%	126.4
Gasconade County	83	246.7 (255.2)	134	346.1 (407.8)	40.3%	99.5
Grundy County	73	304.8 (325.4)	86	359.1 (417.7)	17.8%	54.3
Harrison County	53	283.3 (295.8)	70	336.3 (385.6)	18.7%	53.0
Holt County	29	241.0 (245.6)	45	327.6 (432.0)	36.0%	86.6
Howard County	58	268.3 (271.1)	88	320.1 (406.8)	19.3%	51.8
Howell County	259	314.1 (323.5)	393	408.4 (452.1)	30.0%	94.3
Iron County	113	443.4 (473.3)	148	514.9 (628.0)	16.1%	71.4
Linn County	86	285.6 (298.7)	106	339.8 (398.4)	19.0%	54.2
McDonald County	176	363.9 (369.9)	258	436.4 (495.5)	19.9%	72.5
Marion County	166	271.2 (267.9)	255	336.3 (395.5)	24.0%	65.0

COUNTY	1995-1999		2010-2014		CHANGE IN AGE-ADJUSTED MORTALITY BETWEEN 1995-99 AND 2010-14	
	DEATHS	AGE-ADJUSTED MORTALITY RATE (CRUDE)	DEATHS	AGE-ADJUSTED MORTALITY RATE (CRUDE)	PROPORTIONAL CHANGE (%)	ABSOLUTE CHANGE (DEATHS PER 100,000)
Morgan County	160	364.6 (408.6)	219	433.8 (534.0)	19.0%	69.3
New Madrid County	215	466.6 (474.8)	255	529.0 (607.5)	13.4%	62.4
Ozark County	80	345.0 (384.8)	105	458.8 (540.4)	33.0%	113.8
Pemiscot County	253	595.3 (593.9)	318	725.6 (815.4)	21.9%	130.2
Phelps County	264	313.7 (314.2)	393	391.9 (421.9)	24.9%	78.1
Pike County	121	289.3 (293.3)	171	344.4 (388.5)	19.1%	55.2
Ray County	157	285.2 (290.5)	220	342.9 (413.9)	20.2%	57.7
Reynolds County	70	415.9 (456.8)	83	491.0 (581.3)	18.1%	75.1
Ripley County	123	400.6 (421.4)	172	498.4 (563.1)	24.4%	97.9
Stone County	170	246.6 (274.9)	231	298.7 (359.1)	21.1%	52.1
Texas County	176	327.8 (348.5)	257	394.3 (446.6)	20.3%	66.5
Wright County	138	350.4 (359.3)	199	422.5 (504.4)	20.6%	72.1
MODEST INCREASES IN MORTALITY SINCE 1995-1999 (50 DEATHS OR FEWER PER 100,000) (N=46)						
Adair County	134	292.6 (284.8)	174	332.4 (373.5)	13.6%	39.9
Audrain County	175	307.4 (306.4)	205	311.6 (352.1)	1.4%	4.2
Benton County	159	392.5 (450.7)	211	423.7 (560.2)	7.9%	31.2
Bollinger County	87	324.9 (332.1)	113	346.4 (405.7)	6.6%	21.5
Buchanan County	575	312.5 (300.1)	802	346.1 (385.6)	10.7%	33.6
Butler County	429	451.4 (463.1)	532	481.9 (554.4)	6.7%	30.4
Camden County	250	280.2 (313.3)	358	317.4 (387.0)	13.3%	37.2
Cape Girardeau County	404	275.8 (266.7)	533	285.4 (319.3)	3.5%	9.7
Cass County	481	267.9 (259.3)	733	277.1 (315.1)	3.4%	9.2
Chariton County	49	251.4 (270.0)	62	282.0 (380.5)	12.2%	30.6
Clinton County	134	308.2 (314.8)	169	310.6 (360.6)	0.8%	2.4

COUNTY	1995-1999		2010-2014		CHANGE IN AGE-ADJUSTED MORTALITY BETWEEN 1995-99 AND 2010-14	
	DEATHS	AGE-ADJUSTED MORTALITY RATE (CRUDE)	DEATHS	AGE-ADJUSTED MORTALITY RATE (CRUDE)	PROPORTIONAL CHANGE (%)	ABSOLUTE CHANGE (DEATHS PER 100,000)
Cole County	408	251.2 (229.6)	531	259.1 (286.6)	3.1%	7.8
Dallas County	104	301.2 (308.9)	134	304.2 (369.4)	1.0%	3.0
Douglas County	97	318.7 (343.3)	115	319.4 (399.1)	0.2%	0.7
Franklin County	683	325.7 (316.2)	900	328.6 (376.3)	0.9%	2.9
Gentry County	39	274.9 (287.2)	54	311.3 (378.7)	13.2%	36.4
Greene County	1,722	329.3 (316.9)	2313	344.5 (368.2)	4.6%	15.1
Henry County	181	362.5 (380.9)	233	400.6 (480.3)	10.5%	38.1
Jasper County	801	358.6 (349.1)	1118	390.9 (420.1)	9.0%	32.4
Jefferson County	1,368	302.1 (284.9)	1990	322.5 (366.3)	6.7%	20.4
Laclede County	212	297.0 (298.6)	308	329.2 (384.5)	10.8%	32.1
Lawrence County	242	321.4 (324.8)	323	338.8 (385.0)	5.4%	17.4
Lincoln County	238	295.8 (283.1)	435	300.7 (339.8)	1.6%	4.9
Livingston County	95	282.2 (289.4)	113	296.2 (329.0)	5.0%	14.1
Macon County	97	275.8 (287.5)	121	308.0 (371.0)	11.7%	32.3
Madison County	102	393.9 (403.1)	136	431.5 (501.7)	9.5%	37.6
Maries County	64	316.5 (329.9)	85	334.0 (419.7)	5.5%	17.5
Mercer County	25	284.8 (308.7)	34	325.0 (431.4)	14.1%	40.2
Newton County	386	322.9 (332.1)	530	362.0 (412.2)	12.1%	39.1
Oregon County	101	396.1 (444.2)	113	416.6 (494.1)	5.2%	20.4
Perry County	90	229.0 (224.1)	124	251.5 (287.1)	9.8%	22.5
Pettis County	258	305.3 (298.7)	342	321.4 (359.4)	5.3%	16.1
Polk County	192	350.6 (352.5)	269	366.9 (418.6)	4.6%	16.2
Pulaski County	212	303.0 (241.8)	352	340.3 (305.7)	12.3%	37.3
St. Clair County	87	392.4 (439.4)	106	413.5 (534.7)	5.4%	21.1

COUNTY	1995-1999		2010-2014		CHANGE IN AGE-ADJUSTED MORTALITY BETWEEN 1995-99 AND 2010-14	
	DEATHS	AGE-ADJUSTED MORTALITY RATE (CRUDE)	DEATHS	AGE-ADJUSTED MORTALITY RATE (CRUDE)	PROPORTIONAL CHANGE (%)	ABSOLUTE CHANGE (DEATHS PER 100,000)
St. Francois County	492	398.8 (388.6)	745	429.9 (463.9)	7.8%	31.1
St. Louis County	6,192	254.2 (251.5)	6,944	262.4 (298.4)	3.2%	8.2
Scott County	349	381.7 (379.8)	399	397.5 (451.5)	4.1%	15.8
Shannon County	68	351.8 (364.5)	83	383.8 (456.7)	9.1%	32.0
Shelby County	40	265.7 (275.9)	44	282.9 (331.4)	6.5%	17.2
Stoddard County	278	396.6 (415.5)	323	427.9 (484.5)	7.9%	31.3
Sullivan County	62	383.4 (408.8)	70	400.3 (482.7)	4.4%	16.9
Taney County	269	306.5 (327.9)	446	344.3 (391.9)	12.3%	37.7
Vernon County	172	385.3 (393.1)	220	397.8 (485.3)	3.2%	12.4
Washington County	224	432.5 (423.4)	319	471.6 (529.6)	9.1%	39.2
Webster County	167	256.4 (246.6)	253	271.1 (305.8)	5.7%	14.7
DECREASES IN MORTALITY SINCE 1995-1999 (N=36)						
Andrew County	98	262.2 (264.6)	110	231.7 (277.0)	-11.6%	-30.5
Boone County	683	260.7 (229.7)	927	247.7 (252.1)	-5.0%	-13.0
Caldwell County	72	367.0 (381.0)	74	313.6 (368.8)	-14.5%	-53.4
Callaway County	276	316.9 (297.6)	376	315.2 (358.3)	-0.5%	-1.6
Carter County	65	455.5 (481.0)	69	450.1 (494.7)	-1.2%	-5.4
Christian County	299	266.9 (253.7)	488	241.9 (260.6)	-9.4%	-25.0
Clay County	1,054	251.3 (237.1)	1404	231.5 (250.9)	-7.9%	-19.8
Cooper County	109	325.1 (314.4)	138	302.2 (340.9)	-7.0%	-22.9
Daviess County	59	327.7 (354.4)	64	308.8 (373.2)	-5.8%	-18.9
DeKalb County	93	373.8 (314.3)	116	311.6 (333.2)	-16.6%	-62.2
Hickory County	92	486.9 (527.5)	83	371.5 (477.9)	-23.7%	-115.4
Jackson County	5,747	384.1 (363.3)	6228	350.4 (381.0)	-8.8%	-33.7

COUNTY	1995-1999		2010-2014		CHANGE IN AGE-ADJUSTED MORTALITY BETWEEN 1995-99 AND 2010-14	
	DEATHS	AGE-ADJUSTED MORTALITY RATE (CRUDE)	DEATHS	AGE-ADJUSTED MORTALITY RATE (CRUDE)	PROPORTIONAL CHANGE (%)	ABSOLUTE CHANGE (DEATHS PER 100,000)
Johnson County	258	285.8 (262.0)	333	283.5 (299.3)	-0.8%	-2.3
Knox County	28	283.0 (303.5)	29	280.6 (341.7)	-0.9%	-2.4
Lafayette County	236	314.0 (317.6)	249	276.6 (335.3)	-11.9%	-37.4
Lewis County	76	349.3 (359.9)	82	333.6 (385.1)	-4.5%	-15.7
Miller County	200	388.4 (388.9)	254	374.9 (454.8)	-3.5%	-13.5
Mississippi County	163	527.7 (545.4)	177	473.0 (520.1)	-10.4%	-54.8
Moniteau County	85	277.3 (256.4)	107	263.2 (288.6)	-5.1%	-14.1
Monroe County	76	374.0 (388.1)	53	238.1 (282.5)	-36.3%	-135.9
Montgomery County	105	378.5 (396.1)	107	325.7 (402.9)	-14.0%	-52.9
Nodaway County	108	268.5 (262.6)	106	223.3 (251.5)	-16.8%	-45.2
Osage County	84	300.1 (297.1)	88	241.7 (281.3)	-19.4%	-58.3
Platte County	357	198.4 (192.2)	482	188.6 (211.0)	-4.9%	-9.8
Putnam County	41	345.2 (372.8)	41	328.1 (408.8)	-5.0%	-17.1
Ralls County	65	291.3 (301.7)	77	274.1 (331.6)	-5.9%	-17.2
Randolph County	192	347.7 (333.2)	225	344.7 (377.1)	-0.9%	-3.0
St. Charles County	1,370	224.9 (205.5)	1935	193.8 (215.0)	-13.8%	-31.1
Ste. Genevieve County	120	300.9 (302.0)	134	266.2 (321.1)	-11.5%	-34.7
St. Louis City	4,609	623.9 (562.9)	3,939	467.8 (478.8)	-25.0%	-156.0
Saline County	172	334.1 (340.5)	187	318.8 (371.5)	-4.6%	-15.3
Schuyler County	34	343.9 (374.9)	26	257.9 (289.4)	-25.0%	-85.9
Scotland County	36	365.9 (369.3)	36	331.6 (375.3)	-9.4%	-34.3
Warren County	162	298.3 (300.4)	241	271.4 (317.8)	-9.0%	-26.9
Wayne County	134	431.3 (473.0)	146	419.7 (503.1)	-2.7%	-11.7
Worth County	19	367.7 (397.1)	17	293.0 (385.1)	-20.3%	-74.6

Table 8 sorts the counties by the absolute magnitude of change in death rates between 1995-1999 and 2010-2014. The counties with the largest increases in all-cause mortality were located in the Bootheel and south central regions, including the Ozarks.

Table 8.
COUNTIES SORTED BY ABSOLUTE CHANGE IN AGE-ADJUSTED ALL-CAUSE MORTALITY BETWEEN 1995-1999 AND 2010-2014 AMONG NON-HISPANIC WHITES AGES 25-59 YEARS

COUNTY	ABSOLUTE CHANGE (PER 100,000)	COUNTY (CONTINUED)	ABSOLUTE CHANGE (PER 100,000)	COUNTY (CONTINUED)	ABSOLUTE CHANGE (PER 100,000)	COUNTY (CONTINUED)	ABSOLUTE CHANGE (PER 100,000)
Pemiscot County	130.2	Harrison County	53.0	Maries County	17.5	Miller County	-13.5
Dunklin County	126.4	Bates County	52.9	Lawrence County	17.4	Moniteau County	-14.1
Ozark County	113.8	Stone County	52.1	Shelby County	17.2	Saline County	-15.3
Gasconade County	99.5	Howard County	51.8	Sullivan County	16.9	Lewis County	-15.7
Ripley County	97.9	Mercer County	40.2	Polk County	16.2	Putnam County	-17.1
Dent County	95.8	Adair County	39.9	Pettis County	16.1	Ralls County	-17.2
Howell County	94.3	Washington County	39.2	Scott County	15.8	Daviess County	-18.9
Holt County	86.6	Newton County	39.1	Greene County	15.1	Clay County	-19.8
Barton County	85.2	Henry County	38.1	Webster County	14.7	Cooper County	-22.9
Cedar County	83.6	Taney County	37.7	Livingston County	14.1	Christian County	-25.0
Phelps County	78.1	Madison County	37.6	Vernon County	12.4	Warren County	-26.9
Barry County	77.6	Pulaski County	37.3	Cape Girardeau County	9.7	Andrew County	-30.5
Reynolds County	75.1	Camden County	37.2	Cass County	9.2	St. Charles County	-31.1
Carroll County	74.4	Gentry County	36.4	St. Louis County	8.2	Jackson County	-33.7
McDonald County	72.5	Buchanan County	33.6	Cole County	7.8	Scotland County	-34.3
Wright County	72.1	Jasper County	32.4	Lincoln County	4.9	Ste. Genevieve County	-34.7
Iron County	71.4	Macon County	32.3	Audrain County	4.2	Lafayette County	-37.4
Crawford County	70.1	Laclede County	32.1	Dallas County	3.0	Nodaway County	-45.2
Dade County	69.4	Shannon County	32.0	Franklin County	2.9	Montgomery County	-52.9
Morgan County	69.3	Stoddard County	31.3	Clinton County	2.4	Caldwell County	-53.4
Texas County	66.5	Benton County	31.2	Douglas County	0.7	Mississippi County	-54.8
Marion County	65.0	St. Francois County	31.1	Callaway County	-1.6	Osage County	-58.3
Atchison County	64.7	Chariton County	30.6	Johnson County	-2.3	DeKalb County	-62.2
New Madrid County	62.4	Butler County	30.4	Knox County	-2.4	Worth County	-74.6
Clark County	61.5	Perry County	22.5	Randolph County	-3.0	Schuyler County	-85.9
Ray County	57.7	Bollinger County	21.5	Carter County	-5.4	Hickory County	-115.4
Pike County	55.2	St. Clair County	21.1	Platte County	-9.8	Monroe County	-135.9
Grundy County	54.3	Oregon County	20.4	Wayne County	-11.7	St. Louis City	-156.0
Linn County	54.2	Jefferson County	20.4	Boone County	-13.0		

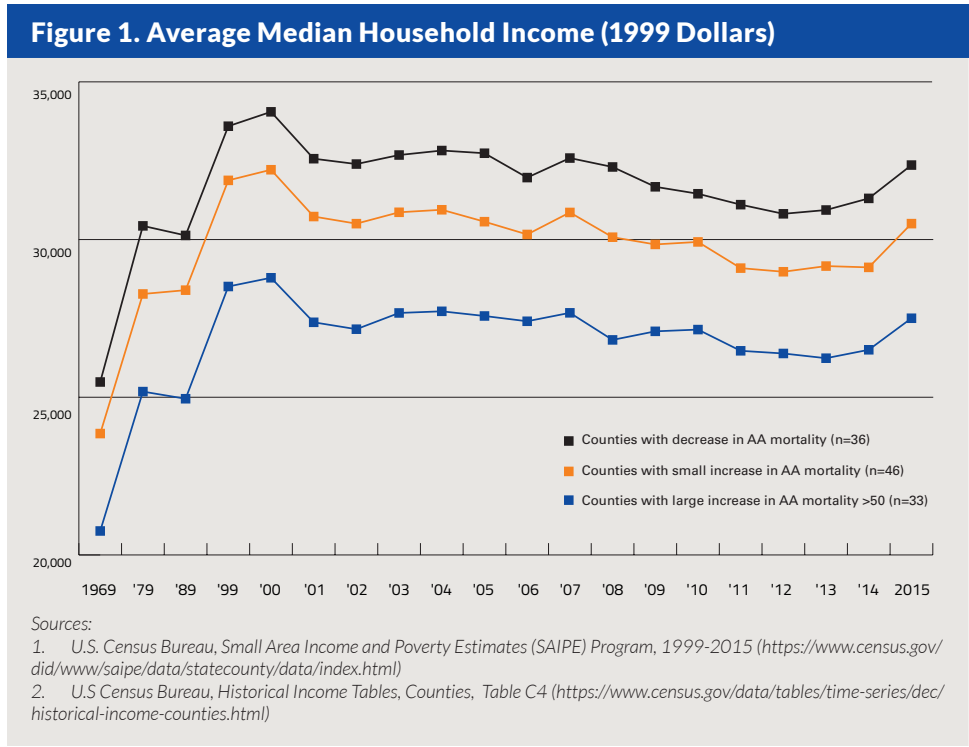
We compared the place-based characteristics of the 36 counties that experienced a decrease in all-cause mortality with the 79 counties where mortality rates increased. Characteristics of interest included not only the rurality of the counties and the demographic characteristics of their populations, but also the socioeconomic status and physical and social environment of the counties. Of special interest was identifying the features that differentiated counties with the largest increases in mortality from those with more modest increases. We found that more heavily impacted counties were more likely to be rural and to have lower socioeconomic status, older housing, and poorer access to health care. Counties with more modest increases in mortality had more urban characteristics, and therefore had not only greater access to parks, food, and public transportation, but also greater exposure to air pollution and violent crime (Table 9).

Table 9.
CHARACTERISTICS OF MISSOURI COUNTIES, BY CHANGES IN ALL-CAUSE MORTALITY AMONG NON-HISPANIC WHITES AGES 25-59 YEARS BETWEEN 1995-99 AND 2010-14

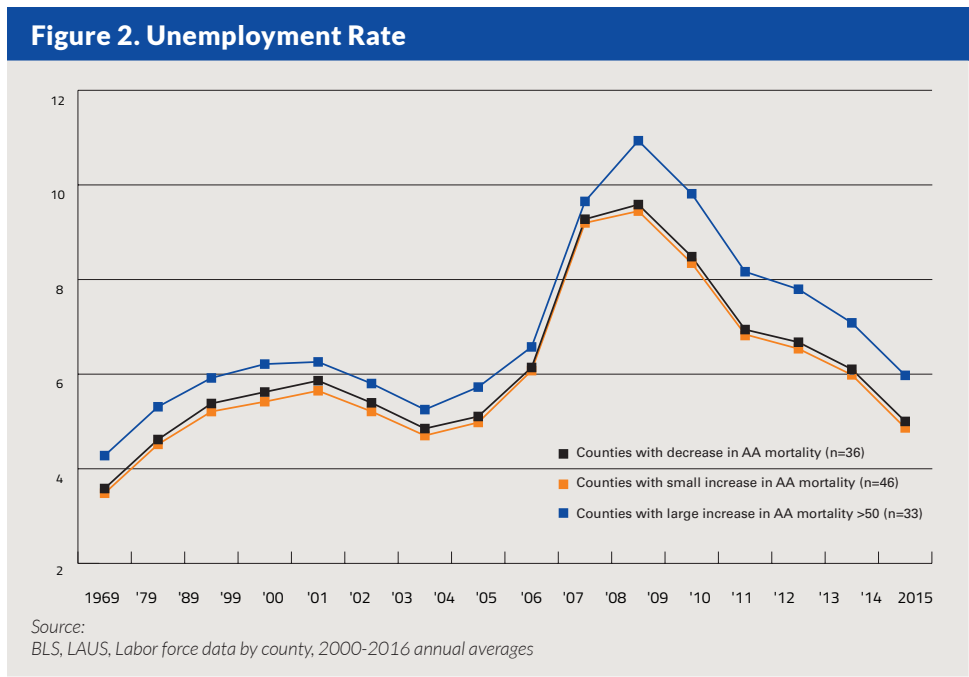
	DECREASES IN MORTALITY (N=36 COUNTIES)	MODEST INCREASES IN MORTALITY (0-50 DEATHS PER 100,000) (N=46 COUNTIES)	LARGE INCREASES IN MORTALITY (> 50 DEATHS PER 100,000) (N=33 COUNTIES)	RATIO (LARGE/MODEST INCREASE)
Geographic Characteristics				
Rural (%)	19.8	29.3	70.8	2.4***
Urban (%)	80.2	70.7	29.2	0.4***
Demographic characteristics				
Single parent households (%)	35.4	31.7	33.6	1.1***
Diversity Index	16.7	16.5	12.9	0.8
Foreign born population (%)	4.5	3.9	1.6	0.4***
Socioeconomic Conditions				
Limited English proficiency (%)	1.2	1.0	0.5	0.5***
Some college or more education (%)	59.7	57.2	41.0	0.7***
Bachelor's degree or more education (%)	29.2	27.0	14.8	0.5***
Unemployment (%)	6.1	6.0	7.0	1.2***
Median household income (\$)	\$44,741.67	\$41,616.11	\$37,880.67	0.9*
Poverty (%)	15.7	14.6	20.3	1.4***
Poverty (adult only, %)	15.1	13.9	19.5	1.4***
Child poverty (%)	20.8	20.0	30.0	1.5***
Gini Index	0.42	0.43	0.43	1.0

	DECREASES IN MORTALITY (N=36 COUNTIES)	MODEST INCREASES IN MORTALITY (0-50 DEATHS PER 100,000) (N=46 COUNTIES)	LARGE INCREASES IN MORTALITY (> 50 DEATHS PER 100,000) (N=33 COUNTIES)	RATIO (LARGE/MODEST INCREASE)
Physical Environment				
Close proximity to highways (%)	3.7	3.2	2.8	0.9***
Ozone days (per year)	7.4	8.0	5.9	0.7
Access to parks (%)	41.9	29.0	16.5	0.6***
Low food access (%)	24.5	21.9	14.4	0.7***
Violent crime rate (per 100,000)	668.6	336.9	263.0	0.8***
Housing				
Overcrowding (%)	1.3	1.4	1.4	1.0
Cost burden (homeowners, %)	22.5	22.3	20.8	0.9***
Cost burden (renters, %)	46.6	44.5	41.5	0.9***
Severe housing disrepair (%)	15.5	14.0	13.3	1.0***
Housing built before 1950 (%)	24.0	16.0	20.0	1.2***
Transportation				
No vehicle access (%)	3.2	2.4	2.5	1.1***
Commuting to work by motor vehicle (%)	91.2	92.6	93.1	1.0***
Commuting to work by public transit (%)	2.2	1.1	0.2	0.2***
Commuting to work by walking/ cycling (%)	2.6	1.9	2.7	1.4***
Access to Health Care				
Primary care physician ratio	1550.1	1233.6	2174.0	1.8***
Mental health provider ratio	653.5	605.3	1118.5	1.8*
Dentist ratio	1832.0	1727.4	3574.6	2.1
Uninsured (%)	12.7	12.5	15.4	1.2***
Public insurance (%)	14.6	15.6	21.5	1.4***
Private insurance (%)	57.7	55.3	42.8	0.8***
<p>See Table 3 for definitions of indicators. P-values calculated using z-test for proportions and t-test for means. * p<.05 ** p<.01 *** p<.001</p>				

We examined how socioeconomic conditions in the impacted counties changed over recent decades. Counties with the largest increases in mortality among non-Hispanic whites had consistently lower median household incomes since the 1970s (Figure 1) and, as shown in the issue brief, had consistently higher poverty rates.



Unemployment rates in Missouri increased sharply after the 2007 Recession, but recovery was slower among counties that experienced the largest increases in mortality. Unemployment rates in these counties continued to climb in 2009 while they were stabilizing elsewhere in Missouri (Figure 2).



Tables 10-11 list the specific causes of death responsible for increasing mortality rates among non-Hispanic whites ages 25-59 years in Missouri. This analysis was based on data for the aggregate of 106 counties that experienced an increase in the crude all-cause mortality rate. We found that most excess deaths were attributable to substance abuse and suicides. The death rate from conditions associated with psychosocial distress and mental illness, such as drug and alcohol abuse and suicide, increased dramatically (Table 10). For example, the mortality rate from accidental drug and alcohol overdoses increased by 585.1% and 762.6%, respectively. These *stress related conditions* included not only accidental overdoses but also medical complications of substance abuse, such as cirrhosis of the liver.

Table 10.
MORTALITY FROM STRESS-RELATED CONDITIONS AMONG NON-HISPANIC WHITES IN AFFECTED COUNTIES†
AGES 25-59 YEARS, MISSOURI, 1995-2014

CAUSE OF DEATH (ICD-10 CODE*)	1995-1999		2000-2004		2005-2009		2010-2014		RELATIVE INCREASE IN MORTALITY RATE (%)§		EXCESS DEATHS FROM 1995-99 TO 2010-2014
	DEATHS (NO.)	AGE-ADJUSTED MORTALITY RATE (CRUDE)	DEATHS (NO.)	AGE-ADJUSTED MORTALITY RATE (CRUDE)	DEATHS (NO.)	AGE-ADJUSTED MORTALITY RATE (CRUDE)	DEATHS (NO.)	AGE-ADJUSTED MORTALITY RATE (CRUDE)	FROM 1995-99 TO 2010-14	FROM 2000-04 TO 2010-14	
Conditions related to drug use											
Accidental drug poisoning (X40-X44)	420	3.5 (3.5)	1,093	8.9 (8.8)	2,199	17.3 (17.1)	3,040	24.1 (23.5)	585.1 (563.5)	170.6 (166.8)	2,548
Sedative-hypnotic, psychotropic, anti-epileptic, and anti-parkinsonian drugs (X41)	NC	NC	105	0.8 (0.8)	157	1.2 (1.2)	263	2.0 (2.0)	NC	138.5 (140.3)	NC
Narcotics and hallucinogens (X42)	NC	NC	489	4.0 (3.9)	1,120	8.8 (8.7)	1,569	12.5 (12.1)	NC	215.6 (207.8)	NC
Other drugs, medicaments and biological substances (X44)	NC	NC	483	3.9 (3.9)	899	7.1 (7.0)	1,186	9.3 (9.2)	NC	137.1 (135.5)	NC
Conditions related to alcohol use											
Alcoholic liver disease (K70)	NC	NC	508	3.9 (4.1)	586	4.2 (4.5)	742	5.2 (5.7)	NC	32.0 (40.1)	NC
Alcoholic cirrhosis of liver (K70.3)	287	2.5 (2.4)	273	2.1 (2.2)	316	2.2 (2.5)	411	2.9 (3.2)	15.4 (NS) (31.3)	36.0 (44.4)	99
Accidental alcohol poisoning (X45.0)	15	0.1 (0.1)	24	0.2 (0.2)	98	0.7 (0.8)	147	1.1 (1.1)	792.6 (798.7)	475.0 (487.7)	130

CAUSE OF DEATH (ICD-10 CODE*)	1995-1999		2000-2004		2005-2009		2010-2014		RELATIVE INCREASE IN MORTALITY RATE (%)§		EXCESS DEATHS FROM 1995-99 TO 2010-2014
	DEATHS (NO.)	AGE-ADJUSTED MORTALITY RATE (CRUDE)	DEATHS (NO.)	AGE-ADJUSTED MORTALITY RATE (CRUDE)	DEATHS (NO.)	AGE-ADJUSTED MORTALITY RATE (CRUDE)	DEATHS (NO.)	AGE-ADJUSTED MORTALITY RATE (CRUDE)	FROM 1995-99 TO 2010-14	FROM 2000-04 TO 2010-14	
Suicide (see notes)	2,014	16.9 (17.0)	2,088	16.8 (16.8)	2,442	19.0 (18.9)	2,862	22.0 (22.1)	30.0 (30.3)	30.7 (31.5)	664
Suicide not involving firearm (see notes)	849	7.1 (7.1)	937	7.6 (7.5)	1,207	9.5 (9.4)	1,366	10.7 (10.5)	50.6 (47.5)	41.6 (39.8)	436
Hanging, strangulation, or suffocation (X70)	265	2.2 (2.2)	359	2.9 (2.9)	512	4.2 (4.0)	708	5.6 (5.5)	156.4 (144.9)	92.1 (89.2)	NC
Narcotics and hallucinogens (X62)	NC	NC	40	0.3 (0.3)	64	0.5 (0.5)	76	0.6 (0.6)	NC	77.8 (82.3)	NC
Other drugs, medicaments and biological substances (X64)	NC	NCN	176	1.4 (1.4)	244	1.9 (1.9)	265	2.1 (2.0)	NC	46.3 (44.4)	224
Suicide by firearm (X72-74)	1,165	9.8 (9.8)	1,151	9.2 (9.3)	1,235	9.5 (9.6)	1,496	11.2 (11.5)	15.0 (17.7)	21.7 (24.7)	228

‡ Affected counties included the 106 counties, listed in Table 5, which experienced a statistically significant increase in all-cause mortality between 1995-99 and 2010-2014.

* ICD-10 codes refer to deaths from 1999 forward. Deaths in 1995-1998 were classified under ICD-9 codes using the conversion dictionary provided in Table 2.

§ All mortality rate increases were statistically significant (p < 0.05) unless otherwise noted as non-significant (NS).

¶ Includes agents primarily acting on smooth and skeletal muscles and the respiratory system anesthetics (general)(local) drugs affecting the: cardiovascular system, gastrointestinal system, hormones and synthetic substitutes, systemic and hematological agents, systemic antibiotics and other anti-infectives therapeutic gases, topical preparations, vaccines, water-balance agents, and drugs affecting mineral and uric acid metabolism.

NA=Not available: Crude mortality rates are not provided if there were fewer than 10 deaths over the five-year period. According to suppression rules, age-adjusted rates are not provided if the average number of deaths per year during the five-year period was less than 10.

NC=No conversion: deaths not reported because deaths during this period (1995-1999) were classified under ICD-9 codes that were not comparable to those in ICD-10. Increases in death rates from 1995-99 (and calculations of excess deaths since that time period) therefore cannot be calculated and also designated as "NC."

NS=Not statistically significant.

Notes: The table focuses on specific causes of death and not overarching categories; a statistically significant increase in age-adjusted mortality rates after 1995-1999 was observed for deaths from "external causes," which includes accidents and injuries. The table omits data on causes of death that did not produce a statistically significant decrease in age-adjusted rates, or those responsible for no more than 100 deaths in any time period. An exception was made for suicides involving narcotics given the public health significance of the current opioid crisis. Population counts for calculating crude rates were 11,879,232 (1995-1999), 12,430,532 (2000-2004), 12,892,531 (2005-2009), and 12,959,789 (2010-2014). ICD-10 codes for suicide included U03, X60-84, and Y87.0; those for suicides not involving firearms included U03, X60-X71, X75-X84, and Y87.0.

Other organ diseases contributed significantly to increasing mortality rates among non-Hispanic whites (Table 11). Behaviors that could be traced to stress may have contributed to these fatal organ diseases, including smoking (chronic lower respiratory disease), drug use (e.g., hepatitis C, liver cancer), and overeating (obesity). Increasing death rates from hypertensive heart disease and heart failure could be linked to alcohol abuse, but other explanations are possible. Further research is needed to determine whether increasing death rates from these diseases are causally linked to accidents, trauma, or heavy sedation associated with overdoses or suicide attempts (e.g., renal failure, sepsis, pneumonitis from aspiration pneumonia, anoxic brain injury) or have independent explanations.

Table 11.

**INCREASED MORTALITY FROM ORGAN DISEASES IN AFFECTED COUNTIES[‡] AMONG NON-HISPANIC WHITES
AGES 25-59 YEARS, MISSOURI, 1995-2014**

CAUSE OF DEATH (ICD-10 CODE*)	1995-1999		2000-2004		2005-2009		2010-2014		RELATIVE INCREASE IN MORTALITY RATE (%) [§]		EXCESS DEATHS FROM 1995-99 TO 2010-2014
	DEATHS (NO.)	AGE- ADJUSTED MORTALITY RATE (CRUDE)	DEATHS (NO.)	AGE- ADJUSTED MORTALITY RATE (CRUDE)	DEATHS (NO.)	AGE- ADJUSTED MORTALITY RATE (CRUDE)	DEATHS (NO.)	AGE- ADJUSTED MORTALITY RATE (CRUDE)	FROM 1995-99 TO 2010-14	FROM 2000-04 TO 2010-14	
PULMONARY DISEASES											
Chronic lower respiratory disease (J40-47)	863	7.5 (7.3)	972	7.2 (7.8)	1,290	8.5 (10.0)	1,500	9.3 (11.6)	24.1 (59.3)	28.2 (48.0)	554
Pneumonitis due to solids and liquids (J69)	68	0.6 (0.6)	90	0.7 (0.7)	112	0.8 (0.9)	158	1.1 (1.2)	81.5 (113.0)	52.7 (68.4)	83
GASTROINTESTINAL DISEASE											
Viral hepatitis (B15-19)	196	1.7 (1.6)	329	2.5 (2.6)	423	2.9 (3.3)	417	2.6 (3.2)	55.6 (95.0)	4.8 (NS) (21.6)(NS)	197
Chronic viral hepatitis C (B18.2)	NC	NC	33	0.3 (0.3)	388	2.6 (3.0)	385	2.4 (3.0)	NC	865.4 (1019.3)	NC
Malignant neoplasm of liver and intrahepatic bile ducts (C22)	224	1.9 (1.9)	320	2.4 (2.6)	467	3.1 (3.6)	561	3.4 (4.3)	72.5 (129.6)	39.8 (68.2)	312
ENDOCRINE DISEASES AND OBESITY											
Obesity (E66)	116	1.0 (1.0)	178	1.4 (1.4)	244	1.8 (1.9)	244	1.8 (1.9)	76.9 (97.3)	26.7 (NS) (31.5)	115
CIRCULATORY DISEASES											
Hypertensive heart disease (I11)	364	3.1 (3.1)	506	3.9 (4.1)	465	3.4 (3.6)	615	4.3 (4.7)	36.9 (54.9)	10.1 (NS) (16.6)(NS)	213
Heart failure (I50)	180	1.0 (1.0)	263	2.0 (2.1)	253	1.7 (2.0)	311	2.0 (2.4)	30.6 (58.4)	3.0 (NS) (13.4)(NS)	112
RENAL CONDITIONS											
Renal failure (N17-19)	191	1.7 (1.6)	405	3.1 (3.3)	495	3.4 (3.8)	555	3.6 (4.3)	119.0 (166.4)	17.7 (NS) (31.4)	338
Chronic renal failure (N18)	58	0.5 (0.5)	170	1.3 (1.4)	216	1.5 (1.7)	276	1.8 (2.1)	255.2 (336.2)	37.4 (55.7)	208
Acute renal failure (N17)	24	0.2 (0.2)	49	0.4 (0.4)	83	0.6 (0.6)	122	0.8 (0.9)	290.9 (366.0)	117.8 (138.8)	95
INFECTIOUS DISEASES											
Septicemia (A40-41)	281	2.4 (2.4)	423	3.2 (3.4)	563	3.9 (4.4)	549	3.6 (4.2)	49.9 (79.1)	13.0 (NS) (24.5)	236

CAUSE OF DEATH (ICD-10 CODE*)	1995-1999		2000-2004		2005-2009		2010-2014		RELATIVE INCREASE IN MORTALITY RATE (%)§		EXCESS DEATHS FROM 1995-99 TO 2010-2014
	DEATHS (NO.)	AGE-ADJUSTED MORTALITY RATE (CRUDE)	DEATHS (NO.)	AGE-ADJUSTED MORTALITY RATE (CRUDE)	DEATHS (NO.)	AGE-ADJUSTED MORTALITY RATE (CRUDE)	DEATHS (NO.)	AGE-ADJUSTED MORTALITY RATE (CRUDE)	FROM 1995-99 TO 2010-14	FROM 2000-04 TO 2010-14	
NEUROLOGIC DISEASES											
Anoxic brain damage, not elsewhere classified (G93.1)	95	0.8 (0.8)	137	1.1 (1.1)	180	1.3 (1.4)	272	1.9 (2.1)	129.0 (162.4)	77.9 (90.4)	167
<p>‡ Affected counties included the 106 counties, listed in Table 5, which experienced a statistically significant increase in all-cause mortality between 1995-99 and 2010-2014..</p> <p>* ICD-10 codes refer to deaths from 1999 forward. Deaths in 1995-1998 were classified under ICD-9 codes using the conversion dictionary provided in Table 2.</p> <p>§ All mortality rate increases were statistically significant (p < 0.05) unless otherwise noted as non-significant (NS).</p> <p>NC=No conversion: deaths not reported because deaths during this period (1995-1999) were classified under ICD-9 codes that were not comparable to those in ICD-10. Increases in death rates from 1995-99 (and calculations of excess deaths since that time period) therefore cannot be calculated and also designated as "NC."</p> <p>NS=Not statistically significant.</p> <p>Notes: The table focuses on specific causes of death and not overarching categories; a statistically significant increase in age-adjusted mortality rates after 1995-1999 was observed for deaths from the following broad categories: diseases of the digestive system, cancer of the digestive organs, and diseases of the endocrine system, nervous system, respiratory system, and genitourinary systems. The table omits data on causes of death that did not produce a statistically significant decrease in age-adjusted rates, or those responsible for no more than 100 deaths in any time period. Population counts for calculating crude rates were 11,879,232 (1995-1999), 12,430,532 (2000-2004), 12,892,531 (2005-2009), and 12,959,789 (2010-2014).</p>											

For more details on the potential causes and policy implications associated with these findings, please see the issue brief, *Why are Death Rates Rising Among Whites in Missouri?*, available at societyhealth.vcu.edu.

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REFERENCES

- ¹Centers for Disease Control and Prevention, NCHS Data Release and Access Policy for Micro-data and Compressed Vital Statistics Files. https://www.cdc.gov/nchs/nvss/dvs_data_release.htm
- ²National Cancer Institute. Surveillance, Epidemiology, and End Results Program. US Population Data. <https://seer.cancer.gov/popdata/popdic.html>
- ³Rothman KJ. *Modern Epidemiology*. Boston, MA: Little, Brown and Company; 1986.
- ⁴Fay MP, Feuer EJ. Confidence intervals for directly standardized rates: A method based on the gamma distribution. *Statistics in Medicine*. 1997; 16:791-801.
- ⁵U.S. Census Bureau, Small Area Income and Poverty Estimates (SAIPE) Program, 1999-2015 (<https://www.census.gov/did/www/saipe/data/statecounty/data/index.html>)
- ⁶U.S Census Bureau, Historical Income Tables, Counties, Table C4 (<https://www.census.gov/data/tables/time-series/dec/historical-income-counties.html>)