ORIGINAL RESEARCH

Progress Toward Achieving National Targets for Reducing Coronary Heart Disease and Stroke Mortality: A County-Level Perspective

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BACKGROUND: The American Heart Association and Healthy People 2020 established objectives to reduce coronary heart disease (CHD) and stroke death rates by 20% by the year 2020, with 2007 as the baseline year. We examined county-level achievement of the targeted reduction in CHD and stroke death rates from 2007 to 2017.

METHODS AND RESULTS: Applying a hierarchical Bayesian model to National Vital Statistics data, we estimated annual age-standardized county-level death rates and the corresponding percentage change during 2007 to 2017 for those aged 35 to 64 and ≥65 years and by urban-rural classification. For those aged ≥35 years, 56.1% (95% credible interval [CI], 54.1%–57.7%) and 39.8% (95% CI, 36.9%–42.7%) of counties achieved a 20% reduction in CHD and stroke death rates, respectively. For both CHD and stroke, the proportions of counties achieving a 20% reduction were lower for those aged 35 to 64 years than for those aged ≥65 years (CHD: 32.2% [95% CI, 29.4%–35.6%] and 64.1% [95% CI, 62.3%–65.7%]), respectively; stroke: 17.9% [95% CI, 13.9%–22.2%] and 45.6% [95% CI, 42.8%–48.3%]). Counties achieving a 20% reduction in death rates were more commonly urban counties (except stroke death rates for those aged ≥65 years).

CONCLUSIONS: Our analysis found substantial, but uneven, achievement of the targeted 20% reduction in CHD and stroke death rates, defined by the American Heart Association and Healthy People. The large proportion of counties not achieving the targeted reduction suggests a renewed focus on CHD and stroke prevention and treatment, especially among younger adults living outside of urban centers. These county-level patterns provide a foundation for robust responses by clinicians, public health professionals, and communities.

Key Words: cerebrovascular disease/stroke ■ coronary heart disease ■ geography ■ mortality rate ■ trends

Cardiovascular diseases (CVDs) are primary causes of mortality in the United States, with heart disease and stroke representing the first and fifth leading causes of death in 2018, respectively.[1] Among deaths attributable to heart disease in 2018, roughly 60% (or 360 000 deaths) were caused by coronary heart disease (CHD).[1,2] Over 140 000 additional deaths resulted from stroke. Two national initiatives, Healthy People 2020 (HP2020) and American Health Association

(AHA) 2020 Impact Goals, were established to address this disease burden and advance efforts to improve cardiovascular health in the decade preceding 2020.[3,4] To that end, both initiatives included objectives aimed at reducing CHD and stroke mortality.

Since 1979, the Healthy People initiative has established nationwide health objectives for each decade.[3] HP2020 included 50 heart disease and stroke objectives, including a 20% reduction in the all-ages CHD

CLINICAL PERSPECTIVE

What Is New?

- Using targets defined by Healthy People 2020 and the American Health Association 2020 Impact Goal, roughly half of US counties achieved the targeted national 20% reduction in coronary heart disease death rates, but only 40% of counties achieved the 20% reduction in stroke death rates.
- Fewer counties achieved the targeted reductions in coronary heart disease and stroke mortality among adults aged 35 to 64 years than among adults aged ≥65 years, and fewer rural counties achieved a 20% reduction in death rates compared with urban counties.

What Are the Clinical Implications?

- These results reinforce the critical need to preserve and improve cardiovascular health across the life course, especially among younger adults and populations living outside of urban centers.

Nonstandard Abbreviations and Acronyms

AHA	American Heart Association
CI	credible interval
HP2020	Healthy People 2020

and stroke death rates to 103.4 and 43.5 deaths per 100 000 population, respectively, by 2020.[3] Similarly, in 2010, the AHA proposed the 2020 Impact Goal: "By 2020, to improve the cardiovascular health of all Americans by 20% while reducing deaths from cardiovascular diseases and stroke by 20%."[4] Because CHD is a major preventable contributor to the overall CVD mortality burden in the United States, the AHA identified a 20% reduction in CHD death rates as a secondary metric.[4] Within the context of stagnating national declines in both CHD and stroke death rates since the establishment of these objectives,[1,5–9] preliminary analyses warned that many national objectives for CHD and stroke mortality were at risk of not being met.[5,10]

Within these national trends, county-level variations in recent heart disease and stroke death rates are more complex.[8,11–15] The highest county-level death rates for both heart disease and stroke are concentrated in the southern United States and in rural counties, with the Stroke Belt containing the highest burden of stroke deaths.[15–17] Despite the national stagnation in declines, some counties have continued to experience strong declines in both heart disease and stroke mortality.[11,12,15] Conversely, many counties have experienced recent increases in heart disease and stroke death rates, reflecting a worsening disease burden.[8,11,12,15] Critically, these recent trends in CHD and stroke death rates have differed markedly by age group, with younger adults experiencing slower declines (and often county-level increases) compared with older adults.[6,8,9,11,12,15]

Within the framework established by the HP2020 and AHA 2020 Impact Goals national initiatives, exploration of disparities in CHD and stroke death rates by age group and geography can provide clinicians, public health professionals, researchers, and communities with data critical to identifying appropriate strategies to improve cardiovascular health. Therefore, these analyses estimated county-level achievement of targeted 20% reductions in CHD and stroke death rates from 2007 to 2017 for adults aged 35 to 64 and ≥65 years.

METHODS

Mortality Data

We obtained annual death counts for CHD and stroke by county of residence and age group from 2007 through 2017 from the National Vital Statistics System of the National Center for Health Statistics. CHD deaths were defined as those for which the underlying cause of death was listed as *International Classification of Diseases, Tenth Revision* (*ICD-10*), codes I20 to I25; stroke deaths were defined as those for which the underlying cause of death was listed as *ICD-10* codes I60 to I69.

The unit of analysis was the county. Given changes in county definitions during the study period (eg, the creation of new counties), we used a single set of 3136 counties based on the most recent county definitions. We used National Center for Health Statistics bridged-race estimates for annual county-level populations.[18]

Statistical Analysis

Estimating County-Level Death Rates

We estimated county-level CHD and stroke death rates and 95% credible intervals (95% CIs) for the years 2007 through 2017 by 10-year age groups using a Bayesian multivariate space-time conditional autoregressive model for each outcome. Additional details of this model are presented below. We then estimated CHD and stroke death rates (per 100 000) for each year and county for those aged ≥35, 35 to 64, and ≥65 years, age standardized using 10-year age groups to the 2000 US standard population (as defined by the 2 national initiatives).[3,4] To summarize the distributions of the estimated death rates across counties, we

calculated the median, 10th, and 90th percentiles of death rates by outcome and age group.

Estimating and Categorizing Percentage Change in Death Rates

We calculated percentage change in death rates as the difference between the 2017 and 2007 rate, divided by the 2007 rate. These years represent the most recent 10-year period for which data were available in January 2020. To summarize the distributions of estimated percentage change in death rates across counties, we calculated the median, 10th, and 90th percentiles of percentage change by outcome and age group.

We then categorized percentage change estimates into 1 of 3 categories of achievement status:

- Achieved 20% reduction: Counties with at least a 20% reduction in death rates from 2007 to 2017 (ie, percentage change ≤−20%).
- Less than 20% reduction: Counties with decreasing death rates from 2007 to 2017, but with a <20% reduction (ie, percentage change >−20% and <0%).
- Increased: Counties that experienced increasing death rates from 2007 to 2017 (ie, percentage change ≥0%).

We calculated the percentage of counties and the percentage of the 2017 population living in counties for each category of achievement status. To further explore geographic patterns within these county-level results, we stratified the results using the 2013 National Center for Health Statistics Urban-Rural Classification Scheme for Counties.[19] This classification includes 6 levels based on the county's population and proximity to metropolitan areas, ranging from the most urban (large central metropolitan counties) to the most rural counties (noncore counties).

Bayesian Spatiotemporal Models

The Bayesian spatiotemporal model in this analysis has been applied extensively to estimate county-level CVD mortality, including death rates attributable to stroke, CHD, and all diseases of the heart.[8,11,12,15] Statistical details of this Bayesian spatiotemporal model have been previously published.[20,21] This model is based on the popular Besag-York-Mollié conditional autoregressive model for spatially referenced count data.[22] It includes the number of deaths as the outcome variable and no independent variables. By iteratively estimating parameters using a Markov chain Monte Carlo algorithm and borrowing statistical strength across space, time, and demographic neighbors, this model generates more precise, reliable rates, even in the presence of small case counts and small populations.[20,23]

The iterative estimation of parameters and the resulting posterior distributions provided another advantage in that they permit all calculations to incorporate uncertainty in the underlying data. We performed all calculations using posterior distributions defined by the Markov chain Monte Carlo iterations. Estimates of county-level rates and percentage change presented in this article are the medians of those posterior distributions. Likewise, achievement status was determined as the status with the largest posterior probability. The calculations of percentage of counties by achievement status and percentage of the population living in those counties likewise accounted for uncertainty in the rate estimates by using the posterior distributions, rather than the point estimates.

All analyses were completed using user-developed code in the R programming language. This code is available on request to the corresponding author. Because all data are publicly available through National Center for Health Statistics, institutional review board approval was not required.

Data Suppression

We considered the rate for a given age group in a given county to be unreliable if the CI width was larger than the point estimate or if the population for the given demographic group in the given year was <500 people.[24] If the estimated death rate for either 2007 or 2017 was unreliable, results for the given county and age group were suppressed. After using these suppression criteria, we included CHD death rates for 3110 (99.2% of counties), 3070 (97.9% of counties), and 2989 (95.3% of counties) counties for those aged ≥35, 35 to 64, and ≥65 years, respectively, and stroke death rates for 3109 (99.1% of counties), 3064 (97.7% of counties), and 2989 (95.3% of counties) counties for those aged ≥35, 35 to 64, and ≥65 years, respectively (Table).

Supplemental Analyses by Race/Ethnicity

Given racial/ethnic disparities in CHD and stroke death rates and their recent trends,[2,5,6] we performed a supplemental analysis to examine patterns of achieving a 20% reduction in CHD and stroke death rates by race/ethnicity. Using the same Bayesian multivariate space-time conditional autoregressive models, we calculated county-level death rates for the following racial/ethnic groups: American Indian/Alaska native, Asian/Pacific Islander, Black, Hispanic, and White groups. Hispanic ethnicity included all races; all races excluded those of Hispanic ethnicity. We used the same denominators, age standardization, and data suppression criteria described above, resulting in the exclusion of many counties with small populations for some racial/ethnic groups.

RESULTS

CHD Death Rates

From 2007 to 2017, the median county-level CHD death rate decreased from 2007 to 2017 across all age groups (aged ≥35 years: from 248.9 in 2007 to 193.6 in 2017 per 100 000; aged 35–64 years: from 62.6 in 2007 to 55.8 in 2017 per 100 000; aged ≥65 years: from 811.9 in 2007 to 604.6 in 2017 per 100 000; Table). The median county-level percentage change in CHD death rates demonstrated reductions for all age groups, but failed to achieve the targeted 20% reduction for those aged 35 to 64 years (10.6% reduction) (Table). For those aged ≥35 years, 56.1% (95% CI, 54.1%–57.7%) of counties, representing 76.6% (95% CI, 75.0%–77.8%) of the population, achieved a 20% reduction in CHD death rates. The percentages of counties achieving a 20% reduction were lower for those aged 35 to 64 years than for those aged ≥65 years (32.2% [95% CI, 29.4%–35.6%] and 64.1% [95% CI, 62.3%–65.7%], respectively) (Table and Figure 1). Conversely, the percentages of counties with increasing death rates were higher for those aged 35 to 64 years than for those aged ≥65 years (32.2% [95% CI, 29.5%–34.7%] and 7.6% [95% CI, 6.6%–8.5%], respectively).

For those aged 35 to 64 and ≥65 years, the highest CHD death rates were concentrated in a band of counties stretching from Oklahoma through West

Virginia (Figure 2). However, the spatial patterns of achieving the targeted 20% reduction were more geographically dispersed. Rural and less urban counties exhibited smaller proportions of counties achieving the 20% reduction and larger proportions of counties with increasing CHD death rates (Figure 3 and Table S1).

Stroke Death Rates

From 2007 to 2017, the median county-level stroke death rate decreased across all age groups (aged ≥35 years: from 91.1 in 2007 to 76.0 in 2017 per 100 000; aged 35–64 years: from 14.2 in 2007 to 13.6 in 2017 per 100 000; aged ≥65 years: from 323.6 in 2007 to 264.9 in 2017 per 100 000) (Table). However, the median county-level percentage change in stroke death rates for all age groups failed to reach a 20% reduction (17.3%, 4.8%, and 18.7% reduction for those aged ≥35, 35–64, and ≥65 years, respectively). For those aged ≥35 years, 39.8% (95% CI, 36.9%–42.7%) of counties, representing 28.0% (95% CI, 25.1%–31.2%) of the population, achieved a 20% reduction in stroke death rates. The proportions of counties achieving the targeted reduction were lower for those aged 35 to 64 years than for those aged ≥65 years (17.9% [95% CI, 13.9%–22.2%] and 45.6% [95% CI, 42.8%–48.3%], respectively) (Table and Figure 1). Conversely, the proportions of counties
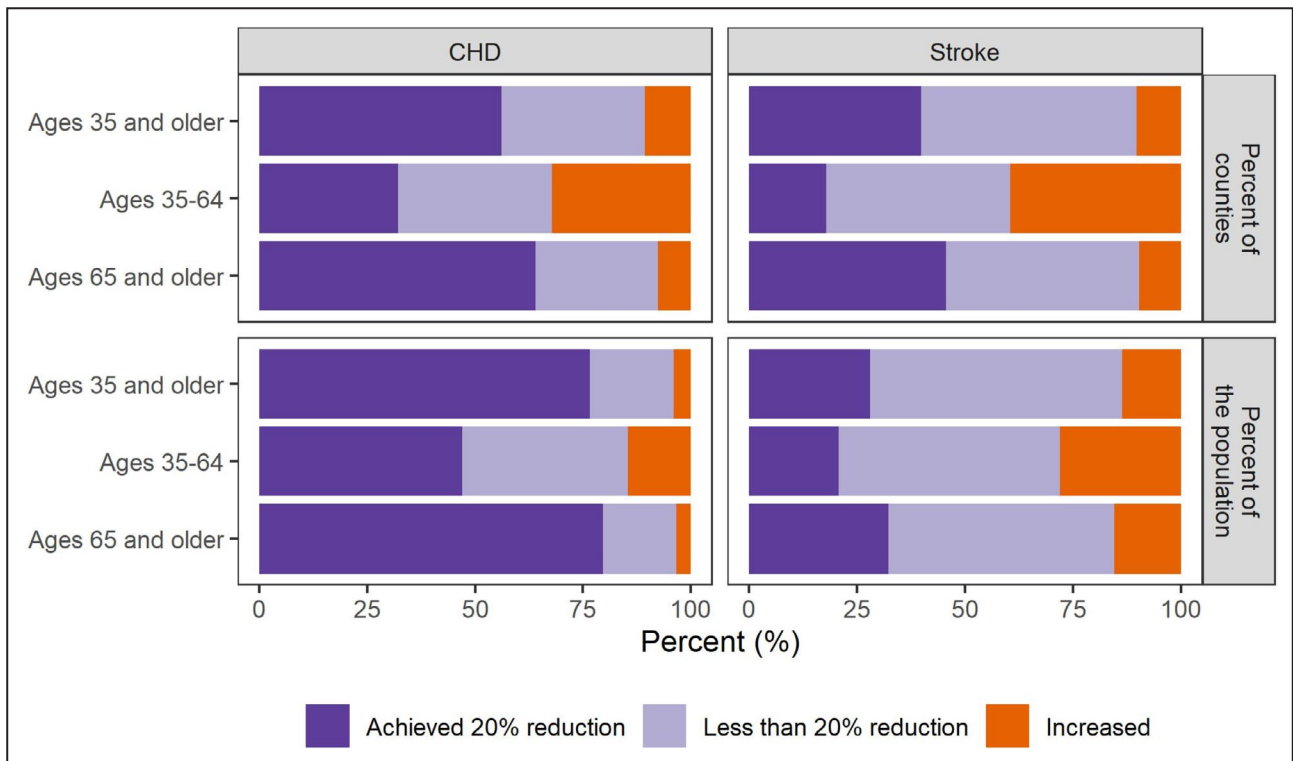
Figure 1. **Percentage of counties and percentage of the population living in those counties by achievement status of coronary heart disease (CHD) and stroke death rates, United States, 2007 to 2017.**
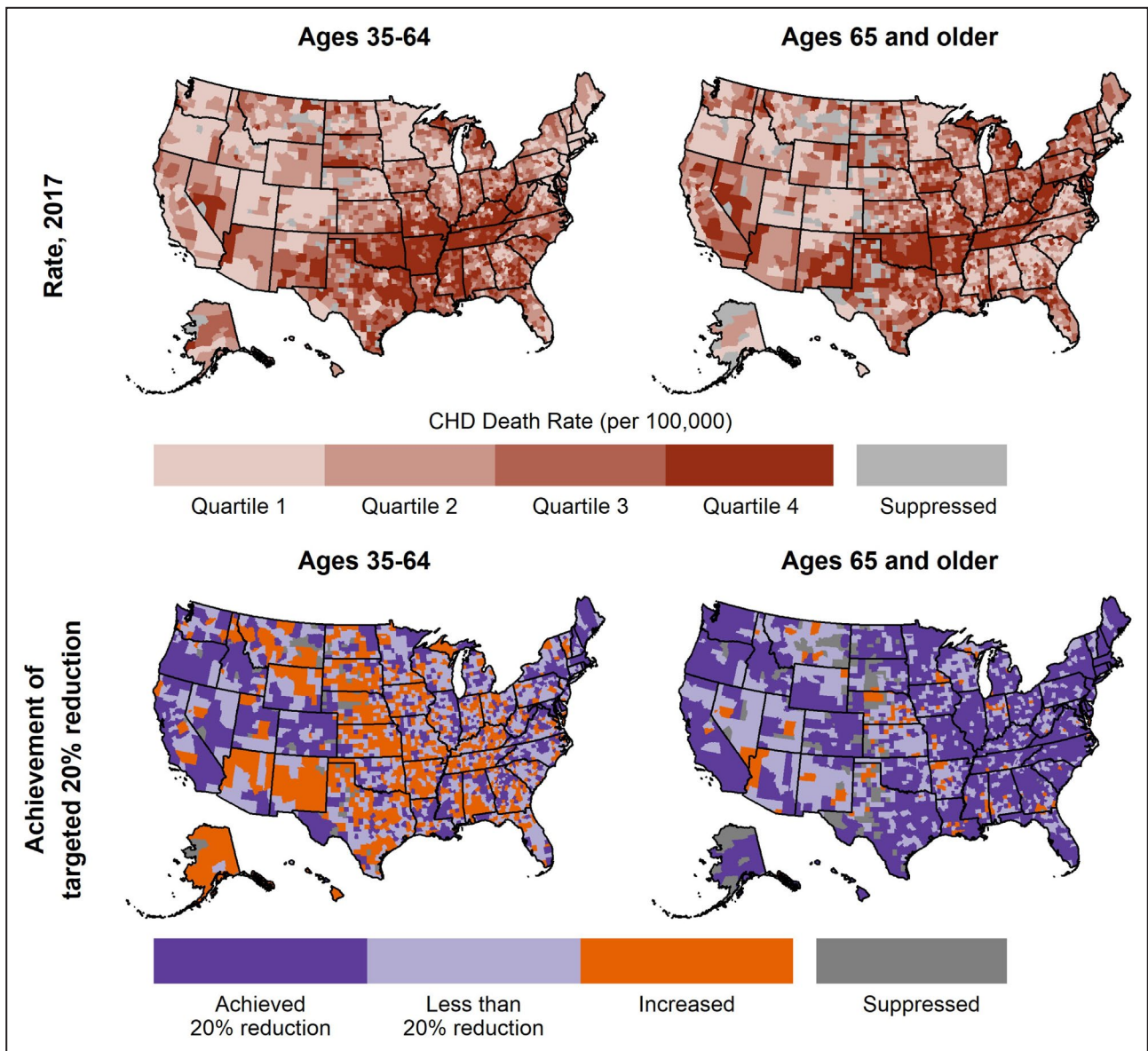
Figure 2. County-level coronary heart disease (CHD) death rates, 2017, and achievement status for CHD death rates by age group, United States, 2007 to 2017.

with increasing rates and the proportions of the population living in those counties were much higher for those aged 35 to 64 years than for those aged ≥65 years (39.4% [95% CI, 35.5%–44.8%] and 9.6% [95% CI, 8.2%–11.1%], respectively) (Table and Figure 1).

For those aged 35 to 64 and ≥65 years, the highest stroke death rates stretched from the southern Atlantic Coast through Arkansas and Louisiana (Figure 4), which forms the well-established Stroke Belt.[16,17] However, counties that achieved the targeted 20% reduction were more geographically dispersed. By urban-rural classification, for those aged 35 to 64 years, large central metropolitan counties had the highest percentage of counties achieving a 20% reduction, and all other

urban-rural classifications had similar percentages of counties (≈15%–20%) achieving a 20% reduction (Figure 3 and Table S1). This pattern was reversed for those aged ≥65 years, with large central metropolitan counties having the smallest percentage of counties achieving a 20% reduction and increasing percentages of counties as the urban-rural classification becomes more rural.

CHD and Stroke Death Rates by Race/Ethnicity

The patterns of achieving 20% reductions in CHD and stroke death rates by age group across race/

Figure 3. County-level stroke death rates, 2017, and achievement status for stroke death rates by age group, United States, 2007 to 2017.
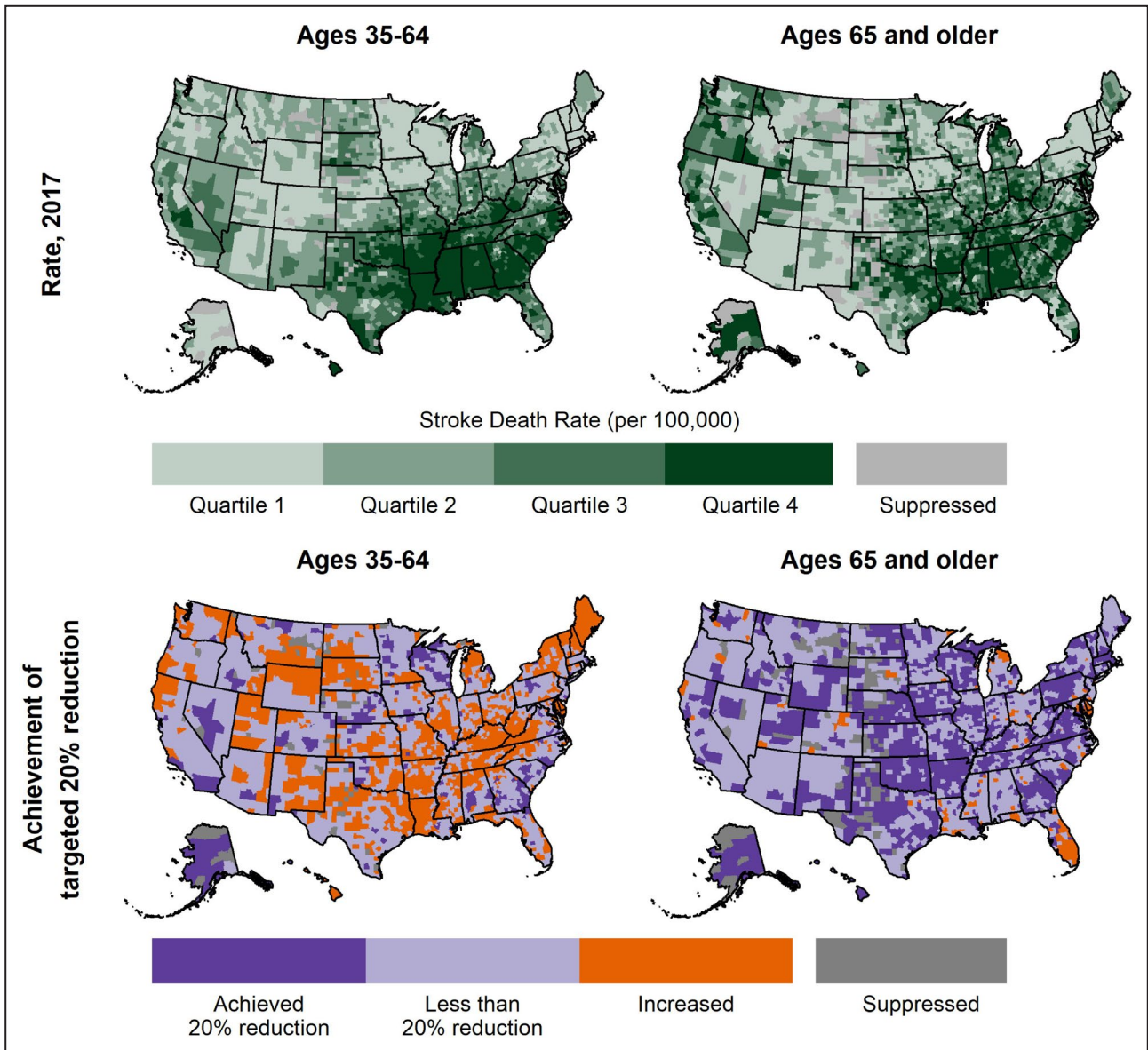
ethnicity were similar to those observed for the total population (Tables S2 through S5). For each racial/ethnic group, the percentages of counties achieving a 20% decline in CHD and stroke death rates were smaller among those aged 35 to 64 years compared with those aged ≥65 years, but there were racial/ethnic differences. For CHD death rates, the percentages of counties achieving a 20% decline among Black populations and Hispanic populations were larger than among White populations for both age groups; for stroke death rates, the percentages for Black, Hispanic, and Asian/Pacific Islander populations were larger than White populations for those aged 35 to 64 years only.

DISCUSSION

Using targets defined by HP2020 and AHA 2020 Impact Goals, our county-level analysis found that more than half of US counties achieved the targeted national 20% reduction in CHD death rates, but only 40% of counties achieved the 20% reduction in stroke death rates. We found variation in achieving the targeted reductions by age group and geography for both heart disease and stroke mortality. Specifically, the proportions of counties achieving targeted reductions in CHD and stroke mortality were smaller among adults aged 35 to 64 years than among adults aged ≥65 years. In addition, we found an urban-rural disparity in county-level
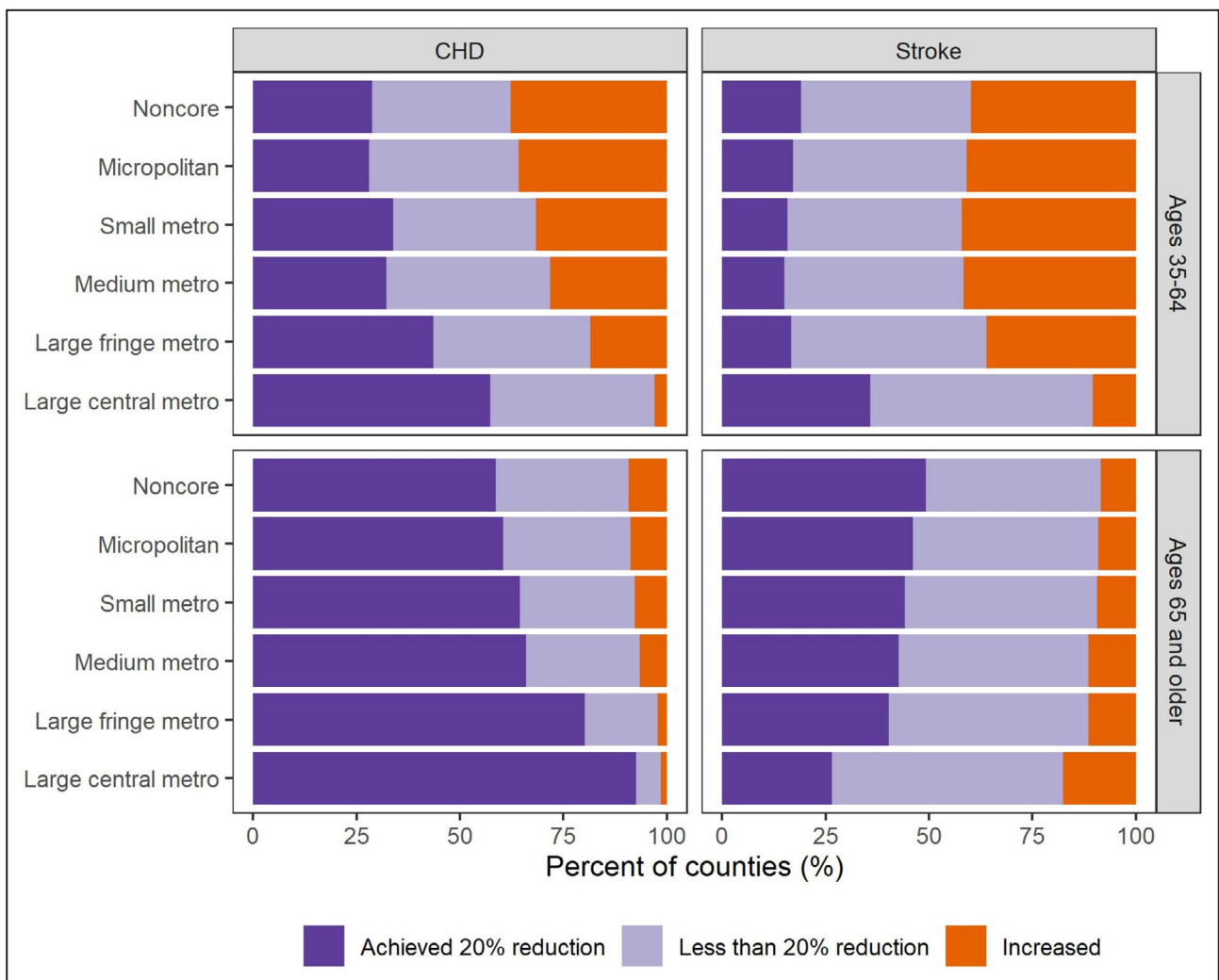
Figure 4. **Percentage of counties by achievement status for coronary heart disease (CHD) and stroke death rates, by age group and urban-rural classification, United States, 2007 to 2017.**
Data are shown in Table S1. Metro indicates metropolitan.

achievement of mortality targets, with urban countries more frequently achieving a 20% reduction in death rates compared with rural counties (except for stroke death rates in those aged ≥65 years).

Disparities in county-level achievement of the targeted 20% reduction in CHD and stroke death rates by age group (and the consistency of that pattern by race/ethnicity) reflect the recent national slowing of declines in CVD mortality,[2,5,9] which are concentrated among younger adults.[8,11,12] These recent trends break with preceding decades of declining national death rates and likely reflect cohort effects in which the growing population burden of traditional CVD risk factors has occurred at successively younger ages.[12,25–27] Consequently, younger adults have also experienced recent increases in both stroke hospitalization and associated stroke risk factors.[28,29] These results reinforce the critical need to preserve and improve cardiovascular health across the life course, especially given the

preventable nature of cardiovascular events and the increased risk of those events when risk factors begin to accumulate before the age of 50 years.[4,30,31]

Observed differences in achievement levels by county characteristics can inform a more focused response in communities that have not achieved the targeted 20% declines. As county-level achievement of a 20% reduction was not confined to those parts of the country with the highest death rates (eg, the Stroke Belt), focusing prevention and treatment resources solely in counties with the highest burden may divert resources from counties with increasing death rates. In addition, the lack of achievement in less urban and rural counties may stem from documented differences in health status and access to care in regions outside urban areas.[32–34] These geographical disparities in CHD and stroke mortality trends further suggest that strictly clinical approaches may not fully address root causes. Efforts to improve death rates in counties that did not

Table. County-Level CHD and Stroke Death Rates, Percentage Change in Death Rates, and Categories of Achievement Status, by Age Group, 2007 and 2017, United States

Variable	CHD			Stroke		
	People Aged ≥35 y	People Aged 35–64 y	People Aged ≥65 y	People Aged ≥35 y	People Aged 35–64 y	People Aged ≥65 y
No. of included counties*	3110	3070	2989	3109	3064	2989
County-level death rate (per 100 000), median (10th to 90th percentile)						
2007	248.9 (177.6 to 347.8)	62.6 (39.5 to 101.2)	811.9 (584.2 to 1128.0)	91.1 (71.5 to 119.0)	14.2 (9.3 to 24.5)	323.6 (255.5 to 415.9)
2017	193.6 (134.8 to 283.2)	55.8 (33.4 to 97.8)	604.6 (431.2 to 860.9)	76.0 (60.1 to 97.2)	13.6 (8.9 to 23.0)	264.9 (211.6 to 329.9)
County-level percentage change, 2007–2017, median (10th to 90th percentile)	−22.2 (−36.4 to −3.5)	−10.6 (−29.4 to 15.0)	−25.7 (−39.1 to −7.4)	−17.3 (−26.8 to −5.8)	−4.8 (−18.4 to 11.1)	−18.7 (−28.9 to −6.7)
Counties, % (95% CI)						
Achieved 20% reduction	56.1 (54.1 to 57.7)	32.2 (29.4 to 35.6)	64.1 (62.3 to 65.7)	39.8 (36.9 to 42.7)	17.9 (13.9 to 22.2)	45.6 (42.8 to 48.3)
<20% reduction	33.3 (31.8 to 34.8)	35.6 (34.0 to 37.2)	28.4 (26.9 to 29.9)	49.9 (47.5 to 52.0)	42.6 (40.5 to 44.6)	44.8 (42.5 to 46.8)
Increased	10.7 (9.7 to 11.9)	32.2 (29.5 to 34.7)	7.6 (6.6 to 8.5)	10.3 (8.9 to 12.0)	39.4 (35.5 to 44.8)	9.6 (8.2 to 11.1)
2017 population, % (95% CI)						
Achieved 20% reduction	76.6 (75.0 to 77.8)	47.0 (42.2 to 50.7)	79.6 (78.2 to 81.0)	28.0 (25.1 to 31.2)	20.8 (15.0 to 27.4)	32.3 (29.4 to 35.4)
<20% reduction	19.4 (18.1 to 21.0)	38.5 (34.4 to 42.9)	17.1 (15.6 to 18.5)	58.3 (54.4 to 62.0)	51.2 (45.1 to 56.9)	52.3 (48.5 to 55.4)
Increased	4.0 (3.5 to 4.5)	14.5 (12.7 to 16.5)	3.3 (2.9 to 3.8)	13.6 (11.4 to 16.4)	28.0 (23.8 to 33.4)	15.3 (12.8 to 17.9)

CHD indicates coronary heart disease; and CI, credible interval.

*Only counties with reliable rates and age group–specific population >500 were included. See Methods for additional details.

achieve a 20% reduction may require an additional focus on underlying social determinants of health.[35–38]

The widespread lack of achievement of the targeted reductions supports the need for policies and programs at the national, state, and local levels aimed at CHD and stroke prevention and treatment. These responses should include evidence-based strategies specific to younger adults and those living outside the most urban counties, and should use coordinated systems of care and macro-level approaches that incorporate economic, political, and social environments.[35–40] Many national initiatives already promote such strategies and could serve as a platform for targeted local responses. For example, the US Centers for Disease Control and Prevention and the Centers for Medicare and Medicaid Services colead the Million Hearts 2022 initiative in collaboration with multiple partners, including the AHA.[40,41] This initiative, which includes adults aged 35 to 64 years as a priority population, aims to implement evidence-based strategies to prevent 1 million acute cardiovascular events through the year 2022.[40] Likewise, the US Centers for Disease Control and Prevention's Paul Coverdell National Acute Stroke Program and the AHA's Get With The Guidelines program develop statewide partnerships to improve the quality of stroke care

and coordinated systems of care to reduce stroke-related death and disability.[42,43] The Target:BP initiative, a collaboration between AHA and the American Medical Association, mobilizes healthcare organizations to improve hypertension control through evidence-based quality improvement interventions across multiple settings.[44] Finally, with the release of its 2030 Impact Goal,[45] AHA expressed a renewed focus on health equity and includes strategies that focus on reducing geographical and other disparities in leading causes of death in the United States (including CHD and stroke).

A key strength of this study is its application of a fully Bayesian spatiotemporal model to national surveillance data. By borrowing statistical strength across adjacent counties, age groups, and years, this model estimated rates that were more precise than other statistical methods, even in counties with small numbers of deaths. Consequently, we included more counties than would be possible with other statistical methods.[23] In addition, this analysis used national vital statistics data that include all recorded deaths.

A primary limitation of this study is the potential misclassification of deaths based on the use of death certificate data. However, the use of death certificates at the aggregate level for surveillance has been validated

and is widely accepted.[46] Local variation in reporting heart disease as the underlying cause of death represents a potential source of bias, but the use of broad *ICD-10* categories for CHD and stroke reduces the potential for misclassification.[47]

CONCLUSIONS

Our analysis of county-level trends in CHD and stroke mortality found that approximately half of US counties achieved the targeted 20% reduction in CHD death rates set forward by the HP2020 and AHA 2020 Impact Goals initiatives, and only 40% of counties achieved the 20% reduction in stroke death rates. Large proportions of US counties either experienced increasing death rates or did not achieve a 20% reduction, highlighting a need for a continued focus on CHD and stroke prevention and treatment, especially among younger adults living outside of urban centers. Documenting these county-level patterns in achieving the targeted 20% reductions in CHD and stroke mortality provides a foundation for robust responses by clinicians, public health professionals, and the communities they serve.

ARTICLE INFORMATION

Affiliations

From the Division for Heart Disease and Stroke Prevention (A.S.V., R.C.W., F.L., M.C.) and Epidemic Intelligence Service (R.C.W.), Centers for Disease Control and Prevention, Atlanta, GA; and Center for Health Metrics and Evaluation, American Heart Association, Dallas, TX (C.M.S.).

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Disclosures

None.

Supplementary Material

Tables S1–S5

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SUPPLEMENTAL MATERIAL

Table S1. Percent of counties (95% CI) by achievement status for coronary heart disease (CHD) and stroke death rates, by age group and urban-rural classification, United States, 2007-2017.

	CHD		Stroke	
	Ages 35-64	Ages 65 and older	Ages 35-64	Ages 65 and older
Achieved 20% reduction				
Noncore (most rural)	28.8 (26.0, 34.0)	19.1 (14.8, 23.7)	58.6 (56.0, 61.1)	49.2 (45.2, 53.3)
Micropolitan	28.0 (24.8, 31.5)	17.1 (12, 22.5)	60.5 (57.1, 63.6)	46.1 (42.6, 50.6)
Small metro	34.1 (28.5, 38.3)	15.8 (10.7, 22.0)	64.5 (60.5, 68.2)	44.2 (39, 48.7)
Medium metro	32.2 (27.9, 35.9)	15.1 (10.8, 19.9)	66.0 (62.8, 69.0)	42.7 (38, 47.8)
Large fringe metro	43.6 (39.5, 47.4)	16.7 (10.9, 22.7)	80.1 (77.1, 83.4)	40.3 (34.9, 45.2)
Large central metro (most urban)	57.4 (48.5, 64.7)	35.8 (23.9, 46.3)	92.6 (88.2, 94.1)	26.5 (19.1, 32.4)
Less than 20% reduction				
Noncore (most rural)	33.5 (31, 35.7)	41 (38.3, 43.8)	32.1 (29.7, 34.7)	42.3 (38.8, 45.4)
Micropolitan	36.1 (32.8, 39.6)	42.1 (38.4, 46.2)	30.7 (27, 34.3)	44.9 (40.4, 48.4)
Small metro	34.4 (29.9, 39.7)	42.1 (37.3, 47.2)	27.8 (23.6, 31.5)	46.4 (41.9, 51.3)
Medium metro	39.7 (35.4, 43.7)	43.3 (37.4, 47.8)	27.4 (23.9, 31)	45.9 (40.5, 50.8)
Large fringe metro	37.9 (33.8, 41.7)	47.3 (41.5, 52.5)	17.7 (14.7, 20.7)	48.2 (43.6, 53.4)
Large central metro (most urban)	39.7 (32.4, 48.5)	53.7 (43.3, 65.7)	5.9 (2.9, 8.8)	55.9 (47.1, 63.2)
Increased				
Noncore (most rural)	37.7 (33.2, 40.7)	39.9 (35.6, 45.2)	9.2 (7.5, 11.1)	8.5 (6.4, 10.8)
Micropolitan	35.8 (32.6, 39)	40.8 (35.8, 45.9)	8.8 (7.1, 10.8)	9.0 (7.2, 11.3)
Small metro	31.5 (27.3, 35.8)	42.1 (35.6, 50.0)	7.7 (5.7, 9.4)	9.4 (6.6, 12.3)
Medium metro	28.2 (24.9, 32.2)	41.7 (36, 47.6)	6.5 (4.6, 8.2)	11.4 (9.0, 14.4)
Large fringe metro	18.5 (15.8, 22.9)	36.1 (29.8, 45.4)	2.2 (1.1, 3.5)	11.4 (8.4, 14.2)
Large central metro (most urban)	2.9 (0, 5.9)	10.4 (4.5, 19.4)	1.5 (1.5, 2.9)	17.6 (11.8, 23.5)

Table S2. Distributions of county-level coronary heart disease (CHD) death rates and percent change by age group and race/ethnicity, 2007 and 2017, United States.

	Number of included counties	Death rate (per 100,000), 2007 (Median (10th, 90th percentiles))	Death rate (per 100,000), 2017 (Median (10th, 90th percentiles))	Percent change, baseline to 2017 (Median (10th, 90th percentiles))
AI/AN				
Ages 35-64	322	51.3 (29.8, 94.1)	51.3 (31.6, 93.7)	3.0 (-21.5, 35.3)
Ages 65 and older	60	756.9 (421.4, 1205.8)	598.4 (263.7, 1034.7)	-22.2 (-43.4, 1.4)
A/PI				
Ages 35-64	481	21.2 (14.9, 31.2)	18.2 (12.5, 27.6)	-15.0 (-36.8, 14.8)
Ages 65 and older	210	422.4 (291.9, 613.5)	309.1 (217.4, 429.9)	-28.5 (-40.0, -5.6)
Black				
Ages 35-64	1311	85.0 (53.2, 139.4)	74.1 (44.1, 128.1)	-12.9 (-36.4, 19.9)
Ages 65 and older	774	847.2 (560.9, 1209.3)	588.4 (384.5, 865.6)	-30.2 (-46.0, -7.5)
Hispanic				
Ages 35-64	1085	31.8 (19.5, 52.9)	25.1 (15.2, 45.4)	-20.2 (-39.8, 6.9)
Ages 65 and older	357	578.0 (336.0, 907.5)	391.7 (220.4, 641.5)	-31.9 (-45.8, -11.4)
White				
Ages 35-64	3011	62.8 (39, 101.7)	56.4 (33.7, 98.8)	-10.2 (-30.1, 17.6)
Ages 65 and older	2932	819.2 (580.2, 1142.8)	613.6 (437.1, 873.8)	-24.8 (-38.6, -6.2)

AI/AN - American Indian and Alaska Native. A/PI - Asian and Pacific Islander. All races exclude Hispanic ethnicity.

Table S3. Percentages of counties and percentages of populations living in those counties by level of reduction in coronary heart disease (CHD) death rates, age group, and race/ethnicity, 2007-2017, United States.

	Percent of counties (95% CI)			Percent of population (95% CI)		
	Achieved 20% reduction	Less than 20% reduction	Increased	Achieved 20% reduction	Less than 20% reduction	Increased
AI/AN						
Ages 35-64	22.0 (14.6, 28.6)	25.2 (19.6, 32.9)	52.8 (41.6, 63.0)	25.6 (12.7, 37.5)	28.0 (19.4, 37.4)	46.5 (35.5, 62.6)
Ages 65 and older	51.7 (41.7, 63.3)	28.3 (18.3, 38.3)	20.0 (10.0, 30.0)	49.6 (38.3, 65.4)	27.9 (15.5, 40.1)	22.5 (7.3, 35.3)
A/PI						
Ages 35-64	42.0 (35.3, 47.4)	26.6 (22.0, 31.4)	31.4 (27.2, 35.8)	47.4 (33.7, 60.2)	29.0 (18.0, 43.6)	23.6 (16.8, 31.1)
Ages 65 and older	65.7 (58.1, 73.3)	22.9 (17.1, 28.6)	11.4 (6.2, 15.2)	75.7 (67.9, 84.3)	19.1 (10.0, 25.5)	5.3 (3.0, 7.9)
Black						
Ages 35-64	39.4 (36.0, 43.0)	28.5 (25.9, 31.1)	32.0 (28.5, 35.5)	48.2 (42.5, 53.2)	33.8 (28.2, 39.4)	18.0 (14.8, 22.2)
Ages 65 and older	70.5 (67.0, 74.0)	20.5 (17.9, 23.1)	9.1 (7.1, 11.4)	84.3 (80.8, 87.0)	12.1 (9.6, 15.4)	3.7 (2.8, 4.8)
Hispanic						
Ages 35-64	49.8 (42.6, 56.4)	26.9 (22.7, 30.4)	23.3 (18.7, 28.8)	51.8 (40.6, 65.4)	36.4 (22.4, 46.1)	11.8 (7.2, 17.4)
Ages 65 and older	73.7 (68.3, 79.0)	19.3 (15.7, 23.5)	7.0 (3.4, 9.8)	86.4 (82.4, 89.5)	11.5 (8.2, 15.3)	2.1 (0.9, 5.0)
White						
Ages 35-64	32.0 (29.5, 33.8)	34.3 (32.2, 36.0)	33.7 (31.3, 36.8)	40.2 (36.8, 43.3)	40.6 (36.8, 44.0)	19.3 (16.7, 21.9)
Ages 65 and older	62.2 (60.2, 64.4)	29.5 (27.7, 31.1)	8.3 (7.1, 9.8)	75.3 (73.5, 77.0)	20.6 (18.6, 22.4)	4.1 (3.4, 4.7)

AI/AN - American Indian and Alaska Native. A/PI - Asian and Pacific Islander. All races exclude Hispanic ethnicity.

Table S4. Distributions of county-level stroke death rates and percent change by age group and race/ethnicity, 2007 and 2017, United States.

	Number of included counties	Death rate (per 100,000), 2007 (Median (10th, 90th percentiles))	Death rate (per 100,000), 2017 (Median (10th, 90th percentiles))	Percent change, baseline to 2017 (Median (10th, 90th percentiles))
AI/AN				
Ages 35-64	363	14.4 (10.7, 19.0)	16.0 (12.0, 20.5)	12.0 (-16.3, 41.3)
Ages 65 and older	59	301.3 (196.6, 395.8)	255.4 (165.8, 343.5)	-11.6 (-28.7, 6.9)
A/PI				
Ages 35-64	538	11.7 (8.7, 15.6)	10.7 (7.3, 14.8)	-11.9 (-31.9, 22.0)
Ages 65 and older	211	237.5 (159.4, 326.9)	210.0 (143.4, 275.6)	-15.1 (-28.6, 11.7)
Black				
Ages 35-64	1326	38.4 (23.9, 55.2)	31.0 (20.6, 44.3)	-17.9 (-32.9, 0.5)
Ages 65 and older	773	421.8 (317.2, 533.8)	338.8 (259.7, 432.7)	-19.7 (-33.6, -0.4)
Hispanic				
Ages 35-64	1126	13.1 (9.4, 18.4)	10.7 (7.8, 16.0)	-16.3 (-33.1, 2.3)
Ages 65 and older	357	236.8 (159.1, 321.0)	209.5 (141.4, 276.6)	-13.1 (-29.5, 14.7)
White				
Ages 35-64	3013	12.6 (8.3, 18.9)	12.4 (8.0, 19.0)	-1.4 (-20.3, 22.1)
Ages 65 and older	2932	317.8 (250.3, 413.7)	262.3 (206.3, 331)	-18.5 (-30.9, -3.1)

AI/AN - American Indian and Alaska Native. A/PI - Asian and Pacific Islander. All races exclude Hispanic ethnicity.

Table S5. Percentages of counties and percentages of populations living in those counties by level of reduction in stroke death rates, age group, and race/ethnicity, 2007-2017, United States.

	Percent of counties (95% CI)			Percent of 2017 population (95% CI)		
	Achieved 20% Reduction	Less than 20% reduction	Increased	Achieved 20% reduction	Less than 20% reduction	Increased
AI/AN						
Ages 35-64	12.6 (6.0, 17.8)	22.4 (16.7, 28.1)	65.0 (55.2, 74.0)	12.9 (5.7, 20.9)	24.3 (15.9, 33.3)	62.8 (50.0, 75.7)
Ages 65 and older	32.2 (20.3, 52.5)	37.3 (23.7, 49.2)	30.5 (13.6, 45.8)	28.7 (19.3, 45.9)	33.0 (19.3, 46.6)	38.3 (18.6, 52.9)
A/PI						
Ages 35-64	33.9 (20.9, 54.0)	30.9 (21.4, 38.9)	35.2 (23.3, 43.4)	38.3 (20.7, 67.1)	35.6 (19.1, 51.4)	26.2 (13.7, 39.1)
Ages 65 and older	36.5 (28.9, 43.1)	37.4 (29.4, 46.4)	26.1 (19.0, 34.6)	38.7 (26.8, 57.0)	45.0 (27.5, 58.2)	16.3 (10.6, 25.3)
Black						
Ages 35-64	46.1 (37.9, 51.2)	35.2 (28.0, 42.8)	18.8 (12.4, 25.2)	49.0 (39.3, 56.1)	38.1 (28.9, 47.4)	12.9 (8.6, 18.1)
Ages 65 and older	47.8 (42.6, 51.4)	35.4 (31.0, 41.8)	16.8 (12.8, 21.0)	35.9 (30.3, 41.2)	38.5 (31.4, 46.5)	25.6 (18.9, 32.0)
Hispanic						
Ages 35-64	42.6 (36.9, 50.7)	35.4 (27.9, 40.9)	22.0 (12.5, 30.0)	42.0 (29.6, 55.9)	42.0 (28.6, 54.0)	16.0 (9.6, 23.8)
Ages 65 and older	34.8 (27.3, 41.2)	35.9 (28.7, 43.2)	29.2 (20.9, 37.0)	25.6 (18.3, 37.9)	45.0 (31.9, 53.3)	29.4 (22.3, 35.9)
White						
Ages 35-64	18.1 (13.7, 22.1)	34.2 (29.4, 40.2)	47.7 (39.3, 53.0)	21.7 (16.0, 27.4)	40.3 (33.9, 46.3)	38.0 (32.4, 43.8)
Ages 65 and older	45.2 (42.3, 48.4)	42.5 (40.2, 44.8)	12.3 (10.5, 13.8)	33.6 (30.8, 36.3)	48.8 (45.9, 52.3)	17.6 (15.2, 20.4)

AI/AN - American Indian and Alaska Native. A/PI - Asian and Pacific Islander. All races exclude Hispanic ethnicity.