

RESEARCH ARTICLE

# Trends in Heart Disease Mortality among Mississippi Adults over Three Decades, 1980–2013

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**Data Availability Statement:** Request and permission to use the Mississippi Vital Statistics data require approval of the Mississippi State Department of Health (MSDH) Institutional Review Board (IRB) (<http://msdh.ms.gov/msdhsite/index.cfm/19,8467,335,32,html>). MSDH IRB application, research proposal and all other required documents should be submitted to the chair of the IRB at [irb@msdh.ms.gov](mailto:irb@msdh.ms.gov).

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## Abstract

Heart disease (HD) remains the leading cause of death among Mississippians; however, despite the importance of the condition, trends in HD mortality in Mississippi have not been adequately explored. This study examined trends in HD mortality among adults in Mississippi from 1980 through 2013 and further examined these trends by race and sex. We used data from Mississippi Vital Statistics (1980–2013) to calculate age-adjusted HD mortality rates for Mississippians age 25 or older. Cases were identified using underlying cause of death codes from the International Classification of Diseases, Ninth Revision (ICD-9: 390–398, 402, 404–429) and Tenth Revision (ICD-10), including I00–I09, I11, I13, and I20–I51. Joinpoint software was used to calculate the average annual percent change in HD mortality rates for the overall population and by race and sex. Overall, the age-adjusted HD mortality rate among Mississippi adults decreased by 36.5% between 1980 and 2013, with an average annual percent change of -1.60% (95% CI -2.00 to -1.30). This trend varied across subgroups: HD mortality rates experienced an average annual change of -1.34% (95% CI -1.98 to -0.69) for black adults; -1.60% (95% CI -1.74 to -1.46) for white adults; -1.30% (95% CI -1.50 to -1.10) for all women, and -1.90% (95% -2.20 to -1.50) for all men. From 1980 to 2013, there was a continuous decrease in HD mortality among adult Mississippians. However, the magnitude of this reduction differed by race and sex.

## Introduction

In recent decades, heart disease (HD) mortality has decreased in the United States (U.S.); however, HD remains the leading cause of death among U.S. adults [1]. HD mortality rates in Mississippi (240.0 deaths per 100,000 population) are higher than the national average (169.8 deaths per 100,000 population) in 2013 [2]. In 2013, HD accounted for 25% of all deaths among Mississippi adults, and blacks and males were disproportionately affected [3]. Researchers have observed similar national-level declines in coronary heart disease (CHD) from 1980–2000 [4] and in the Atherosclerosis Risk in Communities (ARIC) Study which includes the city

of Jackson, Mississippi from 1987–2008 [5]. In addition, decreases in CHD have been observed in other countries and regions, such as Australia [6], England and Wales [7], Sweden [8], Turkey [9], and the European Union [10]. Researchers have attributed these declines to reductions in major risk factors for HD (e.g., cigarette smoking, hypertension, and hyperlipidemia) and evidence-based medical and pharmaceutical therapies that improve disease control (e.g., individuals with hypertension managing their blood pressure) [11,12]. Knowledge of trends in HD mortality can encourage the development of effective prevention and intervention strategies, support public health policies aimed at reducing disparities in HD mortality, and facilitate the achievement of the Healthy People HD objective [13]. However, no previous studies have described annual changes in HD mortality rates in Mississippi. To address this gap, the current study calculated the average annual percent change (AAPC) in age-adjusted HD mortality rates among Mississippi adults ( $\geq 25$  years) between 1980 and 2013. In addition, we examined how AAPC varied by race and sex.

## Materials and Methods

The numbers of adult ( $\geq 25$  years of age) deaths due to HD for each year from 1980 through 2013 were extracted from Mississippi Vital Statistics (available years of data) [3]. We used underlying cause of death codes from the International Classification of Diseases, Ninth Revision (ICD-9: 390–398, 402, 404–429) and Tenth Revision (ICD-10), including I00–I09, I11, I13, and I20–I51, to identify cases [14–16]; ICD-9 was used for the years 1980 through 1999 and ICD-10 was used for later years. We then used Mississippi population census counts to calculate age-adjusted HD mortality rates and standard errors for the overall population, by race (blacks, whites), by sex (women, men), and by race and sex (black women, black men, white women, white men) in SAS 9.4 (SAS Institute Inc.). Age-adjustment was performed using the direct method and the 2000 U.S. standard projected population [8]. Next, we exported age-adjusted HD mortality rates and standard errors to the U.S. Surveillance, Epidemiology, and End Results (SEER) Joinpoint software (4.1.1.5) (<http://surveillance.cancer.gov/joinpoint/>) to calculate the average annual percent change (AAPC) in HD mortality rates for the overall population, by race, by sex, and by race and sex. Joinpoint regression analysis identifies trend breaks (joinpoints) or points of significant change in a trend [10, 15]. This analysis identified time periods with statistically distinct log-linear trends in HD mortality rates [10]. Using a Bayesian information criterion approach to select the most parsimonious model of best fit, we specified a maximum of three joinpoints [7, 8, 10, 17]. The slopes of the models were used to calculate the annual percent change (APC) for each trend segment and the AAPC (the weighted average of the APC) [15]. For each AAPC, 95% confidence intervals (CIs) were calculated and tested to determine whether there was a significant difference from the null hypothesis of no change (0%) [18, 19] using a p-value of  $<0.05$ . This investigation was approved by the Mississippi State Department of Health Institutional Review Board.

## Results and Discussion

During the 33-year period from 1980 through 2013, the age-adjusted HD mortality rate for Mississippi adults decreased by 36.5%, and the AAPC was -1.60% (95% CI, -2.00 to -1.30).

These trends varied by both race and gender. Among black adults, the HD mortality rate decreased by 32.5%, and the AAPC was -1.34% (95% CI, -1.98 to -0.69). Among white adults, the HD mortality rate decreased by 38.1%, and the AAPC was -1.60% (95% CI, -1.74 to -1.46). Among women, the HD mortality rate decreased by 31.6%, and the AAPC was -1.30% (95% CI, -1.50 to -1.10). Among men, the HD mortality rate decreased by 41.4%, and the AAPC was -1.90% (95% CI, -2.20 to -1.50). The results for race-gender subgroups reveal further patterns.

**Table 1. Trends in heart disease age-adjusted death rates among Mississippi adults 25 years and older, 1980–2013: Joinpoint analysis<sup>a</sup>.** CI, confidence interval; APC, annual percent change; AAPC, average annual percent change.

	Trend 1			Trend 2			Trend 3			Trend 4			1980–2013	
	Years	APC <sup>b</sup>	95% CI	Years	APC	95% CI	Years	APC	95% CI	Years	APC	95% CI	AAPC <sup>c</sup>	95% CI
Overall	1980–1997	-0.35	-0.60,-1.00	1997–2009	-3.47	-4.0,-3.0	2009–2013	-1.51	-3.9,1.0	–	–	–	-1.60 <sup>d</sup>	-2.0,-1.3
Black	1980–1983	-1.62	-5.75,2.69	1983–1987	5.03	0.78,9.46	1987–1997	-0.16	-0.87,0.56	1997–2013	-3.54	-3.86,-3.23	-1.34 <sup>d</sup>	-1.98,-0.69
White	1980–1998	-0.44	-0.63,-0.26	1998–2013	-2.97	-3.22,-2.73	–	–	–	–	–	–	-1.60 <sup>d</sup>	-1.74,-1.46
Females	1980–1999	0.52	0.27,0.76	1999–2013	-3.69	-4.07,-3.31	–	–	–	–	–	–	-1.30 <sup>d</sup>	-1.50,-1.10
Males	1980–1997	-0.50	-0.98,-0.03	1997–2013	-3.30	-3.83,-2.77	–	–	–	–	–	–	-1.90 <sup>d</sup>	-2.20,-1.50
Black Females	1980–1989	2.89	1.93,3.86	1989–1999	-0.45	-1.31,0.42	1999–2013	-4.04	-4.51,-3.56	–	–	–	-1.10 <sup>d</sup>	-1.50,-0.70
White Females	1980–2000	0.28	0.09,0.47	2000–2013	-3.52	-3.87,-3.16	–	–	–	–	–	–	-1.20 <sup>d</sup>	-1.40,-1.10
Black Males	1980–1983	-1.95	-6.95,3.31	1983–1989	3.50	1.17,5.89	1989–1997	-1.12	-2.42,0.21	1997–2013	-3.36	-3.76,-2.95	-1.50 <sup>d</sup>	-2.02,-0.80
White Males	1980–1995	-1.05	-1.37,-0.73	1995–2013	-2.82	-3.07,-2.57	–	–	–	–	–	–	-2.00 <sup>d</sup>	-2.20,-1.80

<sup>a</sup>Joinpoint analyses with up to 3 joinpoints yielding up to 4 trends segments (Trends1-4) were based on rates per 100,000 population and were age-adjusted to the 2000 US standard population.

<sup>b</sup>The APC is based on age-adjusted rates to the 2000 US standard population.

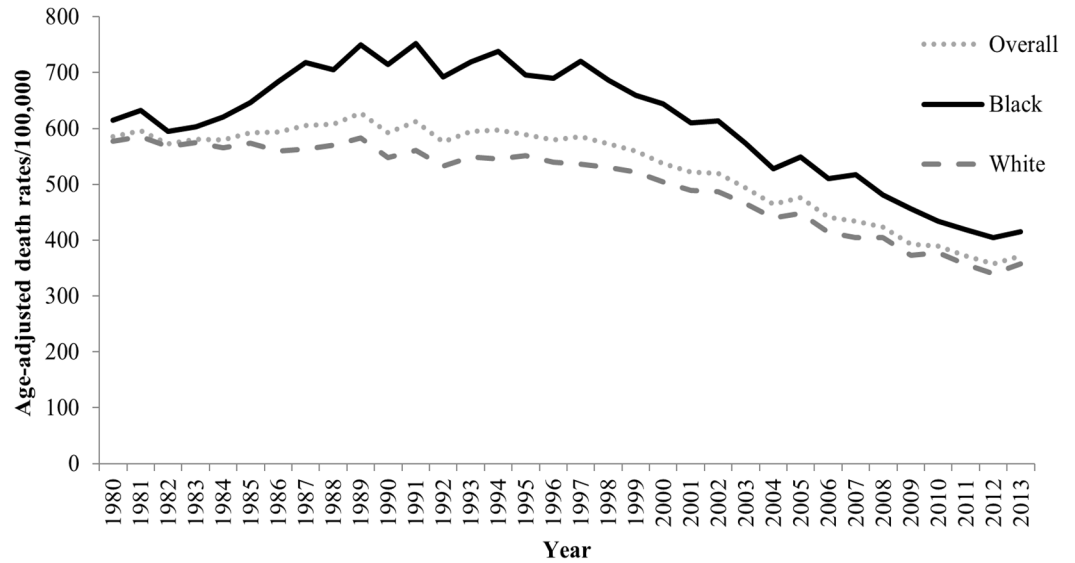
<sup>c</sup>The AAPC is a weighted average of the APCs that is calculated by joinpoint regression.

<sup>d</sup>Significantly different from 0.

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Among black women in Mississippi, the HD mortality rate decreased by 31.7% between 1980 and 2013, and the AAPC was -1.10% (95% CI, -1.50 to -0.70). Among white women, the HD mortality rate decreased by 31.5%, and the AAPC was -1.20% (95% CI, -1.40 to -1.10). Among black men, the HD mortality rate decreased by 33.5%, and the AAPC was -1.50% (95% CI, -2.02 to -0.80). Finally, among white men, the HD mortality rate decreased by 44.4%, and the AAPC was -2.00% (95% CI, -2.20 to -1.80) (Table 1, Figs 1–3, S1–S9 Figs).

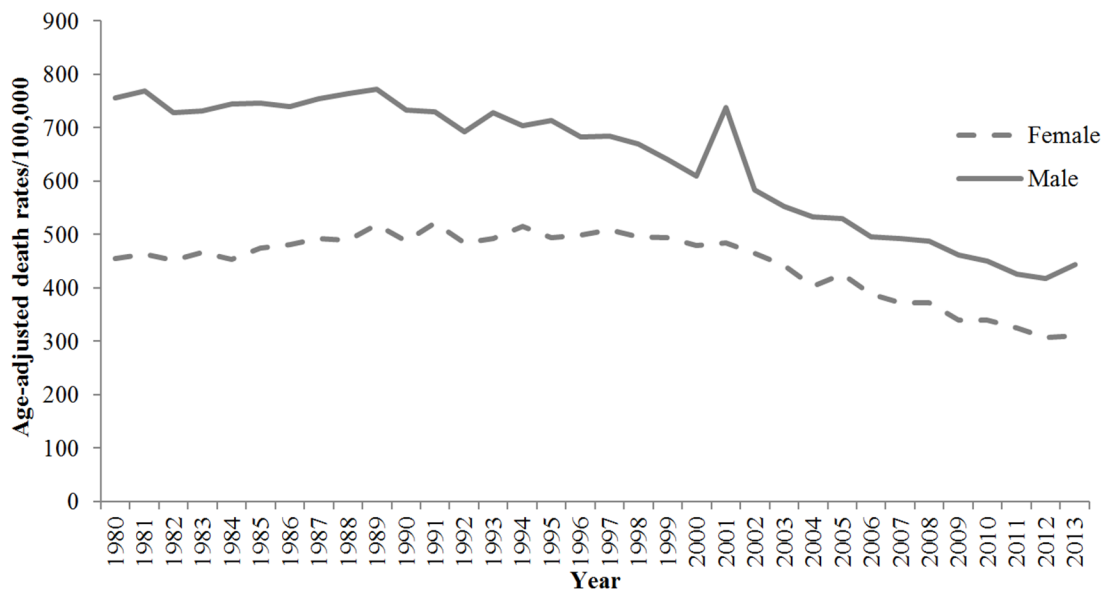
Our analysis of the trends in HD mortality among adult Mississippians revealed a significant decrease from 1980 through 2013, which is consistent with a nationwide decrease from 1973 through 2010 for U.S. adults [16]. While the AAPC in HD mortality rates for Mississippians from 1980 to 2013 (-1.6%) was less than half the national AAPC for 2000 to 2010 (-3.8%) [14], the decrease is nonetheless encouraging given Mississippi’s persistent status as the state with the highest rate of HD mortality in the nation. While the declines in HD mortality among Mississippi adults are consistent with findings for U.S. adults overall [11, 14, 15, 16] the magnitude is smaller in Mississippi [14]. This difference in magnitude may be the result of the state’s prevalence of major risk factors for heart disease (e.g., high blood pressure) being perennially higher than the national level. In addition, Mississippi has a high proportion of black residents (37.0%) [3], and major HD risk factors such as high blood pressure and diabetes disproportionately affect black individuals [1]. The relatively smaller magnitude of the decline in HD mortality in Mississippi should be a red flag to health professionals in the state—a possible signal of a future increase. During the focal period, Mississippi consistently led the nation in obesity and type 2 diabetes prevalence, and the prevalence of smoking and high cholesterol were higher than the national averages [20]. In a recent study of cardiovascular disease (CVD) risk factors



**Fig 1. Trends in age-adjusted HD mortality rates for Mississippi adults  $\geq 25$  years by race, 1980 through 2013.**

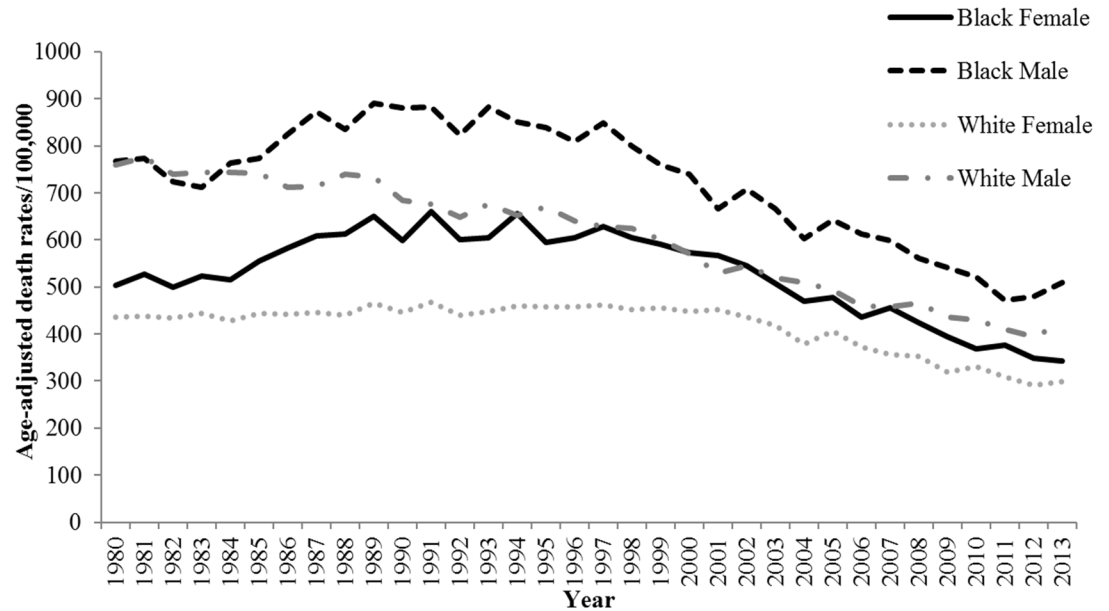
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in the 18-county Mississippi Delta region (a region with a disproportionately high CVD burden) we found statistically significant increases in the prevalence of high cholesterol, diabetes, and obesity [21]. Decades of increases in obesity and diabetes could result in a future increase in CVD mortality [22]. In the U.S., 47% of the decline CHD deaths from 1980–2000 was attributed to evidenced-based medical therapies and 44% was attributed to changes in risk factors [4]. Factors such as a decrease in cigarette smoking, decreases in mean blood pressure and cholesterol levels, improvements in medical care, and changes in diet were found to be responsible for the decline in HD and stroke deaths from 1900 to 1999[12]. During this time period, the country implemented national efforts to reduce HD mortality; for example, the Million Hearts



**Fig 2. Trends in age-adjusted HD mortality rates for Mississippi adults  $\geq 25$  years by sex, 1980 through 2013.**

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**Fig 3. Trends in age-adjusted HD mortality rates for Mississippi adults  $\geq 25$  years by race and sex, 1980 through 2013.**

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initiative, which began in 2012 and aims to prevent one million heart attacks by 2017 [23]. In addition, recent state initiatives have targeted high-burden, underserved, rural areas for HD prevention; one such initiative is the Mississippi Delta Health Collaborative, which serves an 18-county Mississippi Delta region (with a disproportionately high burden of HD). This initiative began in 2010 and aims to prevent HD and stroke and related chronic diseases by focusing on the “ABCS” (aspirin for those at risk, blood pressure control, cholesterol management and smoking cessation) strategy for HD and stroke prevention [21]. Our analysis demonstrated that HD mortality declined significantly for both blacks and whites between 1980 and 2013. However, the magnitude of decline was smaller for blacks. Cardiovascular health disparities between blacks and whites are well documented [24, 25]. For example, blacks are two to three times more likely to die of HD than whites [26]. Social determinants of health disparities such as education, income and income inequality, employment, racism, social networks, risk factor awareness, disease control, access to healthcare, and quality of medical care are associated with higher prevalence of CVD risk factors, morbidity, and mortality [13, 24, 26–29]. In Mississippi, the prevalence of major HD risk factors such as high blood pressure, physical inactivity, obesity, and diabetes are disproportionately higher among blacks than whites [30]. For example, in the 2013 Behavioral Risk Factor Surveillance Systems (BRFSS), blacks had a significantly higher prevalence than whites of both diabetes (14.6% vs. 12.4%) and obesity (43.3% vs. 31.8%). These significant differences in risk factor prevalence may explain the observed racial difference in the magnitude of the decline in HD rates in the state. In addition, the observed magnitude of the HD decline may be attributed to disparities in social determinants of health such as education, income, employment, access to healthcare, and geographical location within the state. For example, data from the 2013 BRFSS show that among Mississippi adults, relative to whites, blacks report higher proportions of not completing high school (24.9% vs. 15.9%), having an annual household income of less than \$10,000 (19.6% vs. 6.3%), and being unemployed (11.2% vs. 5.5%) [30]. Strategies to prevent HD in Mississippi—particularly those aimed at addressing

HD disparities—must include programs to address the social conditions that influence exposure and individual behavior throughout the life course [31].

Among Mississippi residents age 25 and older, HD mortality experienced significant annual declines from 1980 to 2013, but the magnitudes of these declines were lower for women than for men. Gender differences in cultural, social, and behavioral characteristics; socioeconomic status; and biological factors have been linked to the gender gap in CVD mortality rates [32, 33]. For example, in the 2013 BRFSS, men had a significantly higher prevalence of smoking than women (28.0% vs. 22.0%) while women had a significantly higher prevalence of physical inactivity than men (42.3% vs. 33.5%) [30]. From 1980 through 2013, HD mortality rates saw significant annual declines for black men, white men, black women, and white women age 25 and older. The magnitude of decline was smallest for black and white women and highest for white men. The decline among black men was slightly larger than the decline among white and black women but smaller than the decline among white men. In Mississippi in 2013, the prevalence of the primary risk factor for HD (e.g., high blood pressure) was higher among black men (42.1%) than white men (37.5%), and higher among black women (46.1%) than white women (37.0%) [30].

These findings have potential limitations. First, reliance on death certificates may introduce bias due to the misclassification of the underlying cause of death [34, 35] or the decedent's race, [36] which could impact the conclusions drawn from epidemiological studies [37]. However, death certificates are the only data source currently available to assess population trends in heart disease mortality (provided that accuracy does not vary over time) [35], and they allow the description of patterns in the whole population rather than a sample [38]. Second, changes in coding from ICD-9 to ICD-10 may affect the quality of death certificate data, however previous studies have validated the comparability of ICD-9 and ICD-10 in analyzing mortality trends [39, 5]. Finally, findings from a study of coronary heart disease (CHD) deaths in New York City hospitals showed that CHD was overreported as a cause of death on death certificates [40]. The extensive period of study and the analysis of population subgroups are key strengths of the study.

## Conclusions

In conclusion, during the past three decades, HD mortality among adult Mississippians age 25 and older has significantly declined for men, women, black men, black women, white men, and white women. However, the annual magnitude of this decline varied by race and sex. These findings should alert Mississippi public health professionals and policymakers to continually and increasingly support preventive efforts aimed at the major HD risk factors. Such efforts could sustain the decline, particularly among populations who have experienced smaller decreases in HD mortality. Ongoing collaborative efforts between the Centers for Disease Control and Prevention and the Mississippi State Department of Health (through the Mississippi Delta Health Collaborative initiative, MDHC) to implement programs aimed at preventing and reducing the risks of HD and stroke in the Mississippi Delta region ([www.healthymys.com/MDHC](http://www.healthymys.com/MDHC))—a region with a high HD burden—are a step in the right direction.

## Supporting Information

**S1 Fig. Overall trends in heart disease age-adjusted mortality rates among Mississippi adults, 25 years and older, 1980–2013.**

(JPG)

**S2 Fig. Trends in heart disease age-adjusted mortality rates among Mississippi Black adults, 25 years and older, 1980–2013.**

(JPG)



**S3 Fig. Trends in heart disease age-adjusted mortality rates among Mississippi White adults, 25 years and older, 1980–2013.**

(JPG)

**S4 Fig. Trends in heart disease age-adjusted mortality rates among Mississippi Black Female adults, 25 years and older, 1980–2013.**

(JPG)

**S5 Fig. Trends in heart disease age-adjusted mortality rates among Mississippi Black Male adults, 25 years and older, 1980–2013.**

(JPG)

**S6 Fig. Trends in heart disease age-adjusted mortality rates among Mississippi White Female adults, 25 years and older, 1980–2013.**

(JPG)

**S7 Fig. Trends in heart disease age-adjusted mortality rates among Mississippi White Male adults, 25 years and older, 1980–2013.**

(JPG)

**S8 Fig. Trends in heart disease age-adjusted mortality rates among Mississippi Female adults, 25 years and older, 1980–2013.**

(JPG)

**S9 Fig. Trends in heart disease age-adjusted mortality rates among Mississippi Male adults, 25 years and older, 1980–2013.**

(JPG)

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## Author Contributions

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**Formal analysis:** VLM RV LE.

**Investigation:** VLM RV LE.

**Methodology:** VLM RV.

**Supervision:** VLM.

**Validation:** VLM RV LE.

**Writing - original draft:** VLM RV LE.

**Writing - review & editing:** VLM RV LE.

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