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Association Between Employment Factors and Prevalence of Cardiovascular Disease in US Law Enforcement Workers: The National Health Interview Survey, 2006–2018

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Keywords: angina | coronary heart disease | CVD | employment | employment status | heart attack | law enforcement | NHIS | occupation

ABSTRACT

Background: Law enforcement workers face a higher risk of cardiovascular disease (CVD), however, employment factors impacting CVD remain systematically understudied, particularly in a national US sample. We describe temporal trends in prevalent CVD including coronary heart disease (CHD), angina, myocardial infarction (MI) and other heart disease; and investigate associations of select employment factors with CVD among law enforcement workers using the National Health Interview Survey (NHIS) from 2006 to 2018.

Methods: We analyzed prevalent CVD in law enforcement workers employed in local, state, and federal establishments using the NHIS, a nationally representative sample of US workers. We estimated odds ratios (OR [95% confidence interval, CI]) of CVD in relation to employment factors using survey-weighted multivariable logistic regression models adjusted for socio-demographic and traditional CVD risk factors.

Results: Among 2177 law enforcement workers, mean age 46 years, 19% female, prevalence of CVD was higher among disabled (OR = 5.37; 95% CI: 2.53, 11.38 for aggregate CVD outcome) and retired (OR = 2.14; 95% CI: 1.18, 3.88 for aggregate CVD outcome) workers compared to currently employed workers. Workers employed in smaller (1–24 employees) or larger (≥ 500 employees) departments and those with tenure > 20 years also demonstrated higher prevalence odds of select CVD outcomes. Although not statistically significant, higher prevalence odds across CVD outcomes were observed in local government employees, hourly paid workers, and workers with 10–19 years of tenure.

Conclusions: Our study highlights that select employment factors, some previously underexplored, may be associated with prevalent CVD in law enforcement workers. Leveraging national surveys and worker cohorts to enhance surveillance of

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identified groups in this high-risk population could help elucidate the role of employment on CVD development and inform workplace interventions.

1 | Introduction

Cardiovascular diseases (CVD) (coronary heart disease [CHD], angina and myocardial infarction or heart attack) are associated with significant disability and healthcare costs and is the leading cause of death in the United States [1, 2]. Nonetheless, the pathophysiology, prevalence and risk factors associated with CVD in various populations within the United States may be distinct [3–5]. An estimated 70% of major CVD events in US adults were related to having low and moderate cardiovascular health (CVH) [6, 7], with work or occupation implicated as a critical pathway for CVD morbidity and mortality [8–10]. Based on the National Health and Nutrition Examination Survey (NHANES) and National Health Interview Survey (NHIS) data from 2012, an estimated 533,022 CHD cases were reported in adults 20–69 years, 7.8%–21.3% of these CHD cases were attributed to occupation [11]. While it is not fully understood, there is emerging evidence of disparities in CVH and CVD within occupational groups [12–16].

The National Institute for Occupational Safety and Health (NIOSH) has identified first responders or public safety workers including police officers as occupational groups that may be at increased risk of CVD [17, 18]. NIOSH highlighted law enforcement workers among other worker groups in its strategic goals and research priorities encouraging projects, surveillance activities and interventions addressing total worker health and improved data around factors contributing to safety, well-being, and health [19]. Moreover, law enforcement workers are exposed to increased physical and psychosocial stressors related to daily emergency response operations which can impact their CVH and capacity to continue working [18, 20–23]. Prior studies have identified both individual and traditional factors associated with CVD in law enforcement workers including obesity, irregular sleep, hypercholesterolemia, smoking, hypertension, alcohol use, low physical activity, and cardiorespiratory fitness [20–22, 24–29].

Work-related stress, labor force participation, job strain, shift work, long working hours and employment tenure have been previously reported to be related to CVD across various occupations [9, 30–38]. However, the relationship between department size, employer type, and compensation type with CVD which has significant implications for disease prevention as well as organizational interventions and policies has not been investigated in previous research of law enforcement workers thus remaining poorly understood. Broadly in occupational health literature, organizational factors such as employee or department size (small, mid-size, or large) and employer type (municipal, state, federal, or private) impact workload, resource availability, work culture support, work engagement and job satisfaction, which in turn is related to psychosocial stress and adverse health outcomes [39–42]. Compensation type (hourly vs. salaried pay) is also linked to financial stress and job insecurity with downstream influences on worker health outcomes [9, 30, 41].

Furthermore, while associations between specific employment and traditional risk factors of CVD have been explored in a few previous studies focused on single cities, states, and multistate cohorts of law enforcement workers [24, 27–29, 31]; there is a notable lack of research using national data to evaluate trends in the prevalence of CVD and examine employment factors associated with CVD in a representative sample of US law enforcement workers. A national snapshot captures the diversity of law enforcement departments across the United States in relation to demographics, policies and organizational structures providing findings that are broadly applicable to both national and local public health planning, policies and intervention programs. We analyzed data from the NHIS between 2006 and 2018 and evaluated temporal trends in the prevalence of CVD as well as associations of select employment factors with CVD in law enforcement workers.

2 | Methods

2.1 | Data Source

Our study utilized pooled data from the 2006 to 2018 US NHIS cycles ($N = 381{,}989$) conducted by the US National Center for Health Statistics (NCHS), Centers for Disease Control and Prevention, Atlanta, GA, USA [43]. The NHIS is a nationally representative cross-sectional household interview survey of the civilian non-institutionalized population of the United States. The NHIS employs a multistage stratified cluster probability design and randomly selects households for inclusion in the survey. One adult per household is randomly selected for interview in English or Spanish with information collected using computer-assisted personal interviews conducted at the respondents' home or over the telephone [43]. Data from the NHIS is anonymized and publicly available with details of the survey methodology previously published [44, 45]. Ethical approval for the conduct of the NHIS is maintained by the US Office of Management and Budget (#0920-0214) and the research ethics review board of the NCHS (#2018-01).

2.2 | Study Population

Participants included in the present study were adults (aged ≥ 18 years) in protective service occupations who identified as being employed in law enforcement as defined by the US Bureau of Census standard occupation classification (SOC) simple code 12 and detailed code 37 (codes specific to the NHIS survey) [46]. The US Bureau of Census SOC codes for 2000 and 2010 were used to define industry and occupation for the 2006–2009 and the 2010–2018 NHIS cycles, respectively. Law enforcement workers in our study included bailiffs, correctional officers and jailers; detectives and criminal investigators; fish and game wardens; parking enforcement workers; police and sheriff's patrol officers and transit and railroad police [46]. Survey respondents who did not report employment in law enforcement, law enforcement workers employed in the private industry or reporting self-employment and participants missing data

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on one or more outcome and covariate were excluded from our analysis (Figure 1). The final study population included 2177 law enforcement workers.

2.3 | CVD

We evaluated the prevalence of CVD outcomes in law enforcement workers based on response to NHIS survey questions "have you been told by a doctor or other health professional that you had" (1) CHD, (2) angina pectoris, (3) myocardial infarction or heart attack, and (4) other heart disease. Additionally, we assessed CVD by aggregating the four individual outcomes stated above, categorizing participants as either having no self-reported CVD outcome or one or more self-reported CVD outcomes as previously described [47].

2.4 | Employment Factors

We evaluated select employment factors that were consistently assessed across NHIS survey cycles between 2006 and 2018. Labor force participation was defined from responses to questions "what was your employment status in the last week? and what was the main reason for not working in the last week?." We evaluated labor force participation as currently employed and for unemployed or those not in the labor force, participants were categorized as disabled and retired. As previously described, we excluded law enforcement workers reporting private and self-employment. Employee type or class of worker was therefore categorized as local government employee or state and federal government employee and was derived in response to the question "which of these best describes your current job or work situation or the job you held most recently or longest?." Next, we assessed the number of employees at work which was defined by the NHIS survey as 1–24 employees, 25–99 employees, 100–499 employees, and 500 or more employees based on response to the question "how many people work/worked at this location including yourself?." In addition, we evaluated whether law enforcement workers were paid by the hour at their current or most recent job while employee tenure or number of years on the job was evaluated as below 10 years of employment, 10–19 years of employment and 20 or more years of employment.

2.5 | Covariates

We used a directed acyclic graph (DAG) and information from existing literature to identify potential confounders and

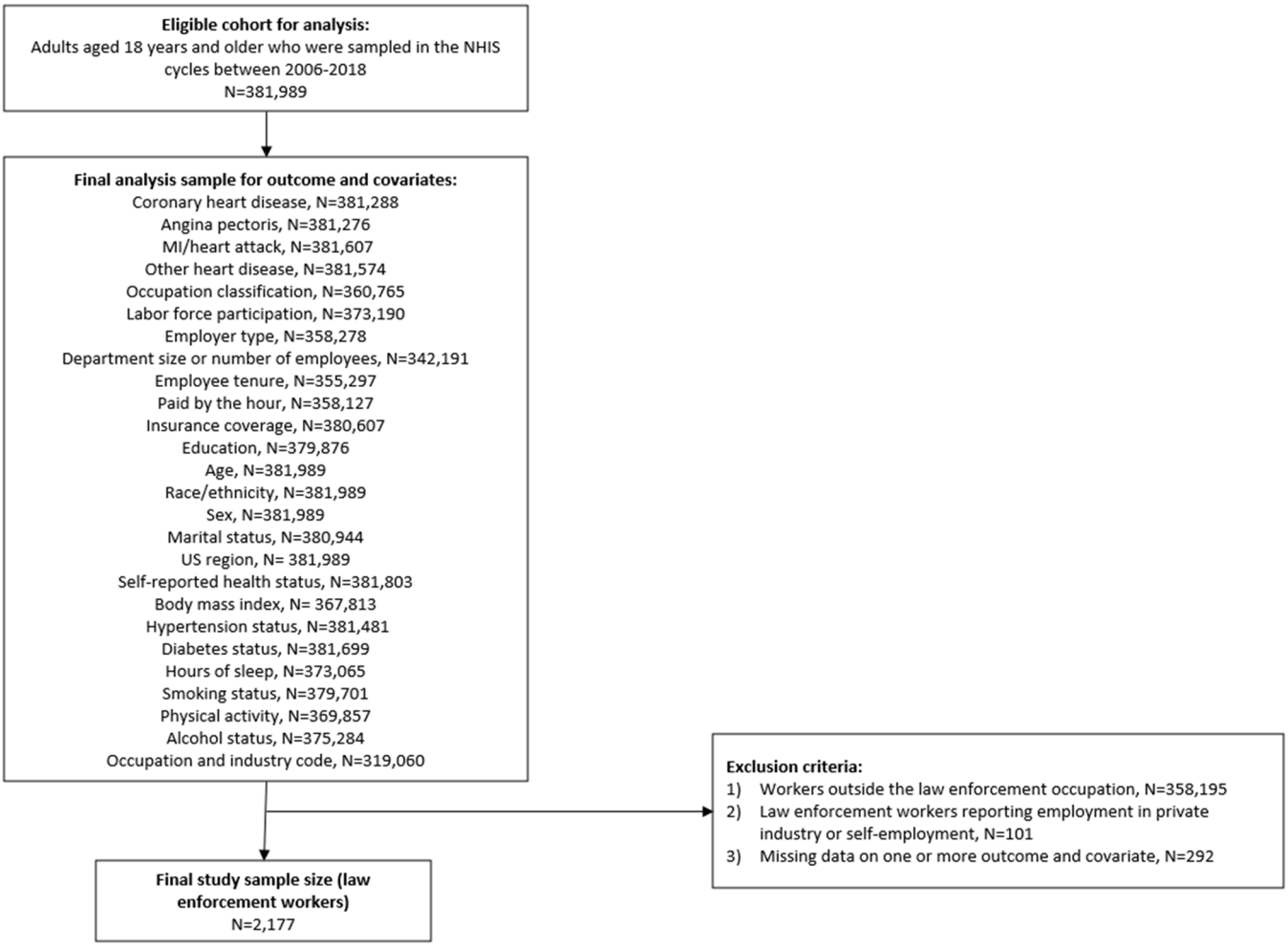

FIGURE 1 | Eligible participants and participants included in the analyses of the association between employment factors and prevalence of cardiovascular disease in US law enforcement workers: the National Health Interview Survey, 2006–2018.

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mediators on the relationship of employment factors with prevalence of CVD outcomes in law enforcement workers (Supporting Information S1: Figure S1) [20–29]. We evaluated age in years (continuous, and dichotomous as 60 years and over or below 60 years based on sample median with CVD), BMI (kg/m^2) calculated using participants' height and weight and categorized as underweight/normal weight, overweight and obese, sex (male or female), US region of respondent categorized as Northeast, Midwest, South and West; education (less than college degree, some college/associate degree, and bachelor's degree or more), marital status (recategorized as married/living with a partner or not married), insurance coverage evaluated as private or other insurance coverage since 98% of law enforcement workers in our analysis reported health insurance coverage, and race/ethnicity (non-Hispanic White or racial ethnic minorities). We aggregated Asian ($N = 24$), American Indian/Alaska Native ($N = 14$), Hispanic/Latino ($N = 272$), non-Hispanic Black ($N = 409$) and other or multiple racial groups ($N = 27$) as racial-ethnic minorities because the limited sample size and proportion of participants reporting CVD in these groups impacted coefficients of variation and prevalence estimates.

We also included lifestyle factors related to CVD such as smoking status (never smoker, former smoker, and current smoker), alcohol consumption status (lifetime abstainer, former infrequent drinker and current drinker), and physical activity categorized as no or insufficient physical activity if the participant reported engaging in no exercise or reported < 150 min a week of light to moderate physical activity or < 75 min a week of vigorous physical activity; and sufficient physical activity if the participant reported > 150 min a week of light to moderate physical activity or > 75 min a week of vigorous physical activity per the Physical Activity Guidelines Advisory Committee Scientific Report [48]. We also evaluated potential mediators such as self-reported health status (excellent or very good, good and fair, or poor), self-reported hours of sleep, diabetes or prediabetes and hypertension status defined from participants' responses to the question "have you ever been told by a doctor or other health professional that you have (1) diabetes or prediabetes and (2) hypertension?." We did not include information on diet and high cholesterol since they were not collected uniformly by the NHIS across cycles evaluated in the present analysis.

2.6 | Statistical Analyses

We pooled the 2006–2018 NHIS data to increase our analytical sample and precision of estimates, and constructed new 13-year weights calculated as one-thirteenth of sample adult weights (WTFA_SA) for the 2006–2018 cycles based on data analysis recommendations by the NCHS [43, 44]. For the descriptive analyses, we evaluated survey-weighted means [95% CI] for continuous variables and prevalence [95% CI] for categorical variables. Survey-weighted multivariable logistic regression models were used to evaluate associations of occupational factors with prevalent CVD outcomes in law enforcement workers. First level models adjusted for survey cycle, age, sex, private insurance status, non-Hispanic white ethnicity, BMI, smoking status, physical activity and alcohol consumption status. Sensitivity analyses adjusted for variables in first level models plus select mediators—hypertension and diabetes status to evaluate whether their inclusion changed estimates of association between employment factors and CVD outcomes. SAS software (v 9.4; Cary, NC) and Stata/SE version 18.0 (StataCorp LLC) were used for the statistical analyses.

3 | Results

3.1 | Sample Characteristics and Prevalence of CVD Outcomes in Law Enforcement Workers

Our study included 2177 participants aged 18–85 years of age (mean age of 45.9 years) who reported employment in law enforcement. Participants in our study were primarily non-Hispanic white, married, male, had some college or associates degree and private insurance, lived in the Southern US region, overweight, nondiabetic, nonhypertensive, never smokers, physically active, current drinkers, and self-reported excellent or very good health status (Table 1). The prevalence of CVD outcomes between 2006 and 2018 ranged from 2.61% (95% CI: 1.82%, 3.41%) for angina, 3.47% (95% CI: 2.55%, 4.40%) for MI, 5.98% (95% CI: 4.64%, 7.30%) for CHD and 6.82% (95% CI: 5.41%, 8.24%) for other heart disease (Table 1). We observed higher prevalence across all CVD outcomes in law enforcement workers who had no private insurance, less than some college degree, were 60 years and older, obese, non-Hispanic white, hypertensive, diabetic or prediabetic, current and former smokers, physically inactive, former infrequent drinker and those who reported fair or poor health status (Table 1). Prevalence estimates varied across individual CVD outcomes by sex and US region (Table 1).

3.2 | Temporal Trends in Prevalence of CVD Outcomes in Law Enforcement Workers

Our analysis evaluating temporal trends in prevalence of CVD outcomes demonstrated significant increase in trend for only MI ($p = 0.013$; Figure 2c). This increase in the temporal trend of prevalent MI was significantly different in law enforcement workers compared to active nonprotective service workers ($p = 0.007$; Supporting Information S1: Figure S2c). We did not observe significant change in temporal trends for CHD, angina and other heart disease (Figure 2a,b,d and Supporting Information S1: Figure S2a,b,d). In addition, findings of temporal trends in prevalent CVD were consistent in sensitivity analysis of only currently employed law enforcement workers excluding retired and disabled workers (not shown in figures).

3.3 | Employment Characteristics and Prevalence of CVD Outcomes in Law Enforcement Workers

Prevalence of CVD outcomes ranged between 41%–61%, 10%–18%, and 21%–49% for retired, disabled and currently employed law enforcement workers, respectively (Table 2). The prevalence of law enforcement workers with CVD varied by department size and was higher across CVD outcomes for

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TABLE 1 | Sample characteristics and prevalence [95% CI] of cardiovascular disease in law enforcement workers[a]: the National Health Interview Survey—2006 to 2018 ($N = 2177$)[c].

	Coronary heart disease			Angina		MI/heart attack		Other heart disease	
	Total	No	Yes	No	Yes	No	Yes	No	Yes
Characteristics, %	$N = 2177$	$n = 2044$ [94.1%]	$n = 133$ [5.9%]	$n = 2115$ [97.4%]	$n = 62$ [2.6%]	$n = 2092$ [96.5%]	$n = 85$ [3.5%]	$n = 2,025$ [93.2%]	$n = 152$ [6.8%]
Insurance coverage									
Other coverage	14% [12%, 16%]	13% [11%, 15%]	33% [22%, 45%]	13% [11%, 15%]	43% [28%, 59%]	13% [11%, 15%]	37% [24%, 50%]	13% [11%, 15%]	28% [18%, 38%]
Private coverage	86% [84%, 88%]	87% [85%, 89%]	67% [55%, 78%]	87% [85%, 89%]	57% [41%, 72%]	87% [85%, 89%]	63% [50%, 76%]	87% [85%, 89%]	72% [62%, 82%]
Educational attainment									
Less than college degree	23% [21%, 26%]	23% [20%, 25%]	35% [24%, 45%]	23% [21%, 25%]	31% [17%, 46%]	23% [20%, 25%]	41% [28%, 53%]	23% [21%, 25%]	27% [18%, 36%]
Some college/associate degree	44% [42%, 47%]	45% [42%, 47%]	42% [31%, 54%]	44% [42%, 47%]	46% [30%, 61%]	45% [42%, 47%]	40% [27%, 52%]	45% [42%, 47%]	44% [33%, 54%]
Bachelor's degree or more	32% [30%, 35%]	33% [30%, 35%]	23% [14%, 32%]	32% [30%, 35%]	23% [10%, 36%]	33% [30%, 35%]	20% [8%, 31%]	32% [30%, 35%]	30% [20%, 39%]
Age [years]; mean [95% CI]	45.9 [45.03, 46.71]	44.6 [43.75, 45.40]	66.3 [63.76, 68.80]	45.3 [44.51, 46.18]	65.6 [62.20, 69.06]	45.2 [44.39, 46.07]	63.8 [60.69, 66.88]	45.1 [44.19, 45.92]	57.1 [54.24, 59.88]
Less than 60 years	80% [77%, 82%]	83% [81%, 85%]	30% [18%, 42%]	81% [79%, 83%]	29% [15%, 42%]	81% [79%, 83%]	19% [17%, 21%]	82% [80%, 84%]	50% [39%, 61%]
60 years and over	20% [18%, 23%]	17% [15%, 19%]	70% [58%, 82%]	19% [17%, 21%]	71% [58%, 85%]	38% [25%, 51%]	62% [49%, 75%]	18% [16%, 20%]	50% [39%, 61%]
Hours of sleep; mean [95% CI]	6.90 [6.83, 6.96]	6.88 [6.82, 6.94]	7.14 [6.83, 7.45]	6.88 [6.82, 6.94]	7.49 [7.02, 7.96]	6.88 [6.82, 6.95]	7.26 [6.83, 7.69]	6.90 [6.84, 6.97]	6.77 [6.51, 7.03]
Body mass index [kg/m^2]; mean [95% CI]	29.7 [29.36, 30.10]	29.6 [29.29, 29.98]	31.3 [28.21, 34.36]	29.7 [29.35, 30.10]	30.1 [28.25, 31.86]	29.7 [29.33, 30.08]	30.5 [29.00, 31.93]	29.6 [29.29, 29.98]	31.1 [28.38, 33.78]
Underweight/Normal	18% [16%, 19%]	17% [15%, 19%]	20% [11%, 28%]	17% [16%, 19%]	19% [6%, 31%]	17% [16%, 19%]	18% [8%, 28%]	18% [16%, 20%]	18% [11%, 24%]
Overweight	44% [41%, 47%]	45% [42%, 47%]	32% [22%, 42%]	44% [41%, 47%]	34% [21%, 48%]	44% [42%, 47%]	28% [17%, 39%]	44% [42%, 47%]	37% [27%, 47%]
Obese	39% [36%, 41%]	38% [35%, 41%]	48% [37%, 59%]	38% [36%, 41%]	47% [31%, 63%]	38% [35%, 41%]	54% [41%, 67%]	38% [35%, 41%]	45% [34%, 56%]
Race/Ethnicity									
Racial-ethnic minorities[b]	31% [28%, 34%]	32% [30%, 35%]	10% [5%, 14%]	31% [29%, 34%]	22% [11%, 33%]	31% [29%, 34%]	22% [12%, 32%]	32% [30%, 35%]	14% [8%, 20%]

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TABLE 1 | (Continued)

Characteristics, %	Total $N = 2177$	Coronary heart disease		Angina		MI/heart attack		Other heart disease	
		No $n = 2044$ [94.1%]	Yes $n = 133$ [5.9%]	No $n = 2115$ [97.4%]	Yes $n = 62$ [2.6%]	No $n = 2092$ [96.5%]	Yes $n = 85$ [3.5%]	No $n = 2,025$ [93.2%]	Yes $n = 152$ [6.8%]
Non-Hispanic White	69% [66%, 72%]	68% [65%, 70%]	90% [86%, 95%]	69% [66%, 71%]	78% [67%, 89%]	69% [66%, 71%]	78% [68%, 88%]	68% [65%, 70%]	86% [80%, 92%]
Sex									
Male	81% [79%, 83%]	80% [78%, 82%]	89% [82%, 95%]	81% [79%, 83%]	74% [60%, 89%]	81% [79%, 82%]	89% [81%, 98%]	81% [79%, 83%]	80% [73%, 87%]
Female	19% [17%, 21%]	20% [18%, 22%]	11% [5%, 18%]	19% [17%, 21%]	26% [11%, 40%]	19% [18%, 21%]	11% [2%, 19%]	19% [17%, 21%]	20% [13%, 27%]
Marital status									
Married	72% [70%, 74%]	72% [70%, 74%]	70% [61%, 79%]	72% [70%, 75%]	57% [42%, 73%]	72% [70%, 74%]	68% [58%, 79%]	72% [70%, 74%]	75% [68%, 83%]
Not Married	28% [26%, 30%]	28% [26%, 30%]	30% [21%, 39%]	28% [25%, 30%]	43% [27%, 58%]	28% [26%, 30%]	32% [21%, 42%]	28% [26%, 30%]	25% [17%, 32%]
Region									
Northeast	20% [17%, 22%]	20% [17%, 22%]	22% [10%, 33%]	20% [18%, 23%]	3.6% [1%, 7%]	20% [17%, 22%]	23% [12%, 34%]	20% [17%, 22%]	22% [10%, 34%]
Midwest	18% [16%, 20%]	17% [15%, 20%]	29% [19%, 38%]	18% [16%, 20%]	22% [8%, 35%]	18% [16%, 20%]	19% [8%, 29%]	17% [15%, 20%]	27% [18%, 36%]
South	42% [39%, 45%]	42% [39%, 45%]	36% [25%, 46%]	41% [38%, 44%]	61% [47%, 75%]	42% [39%, 45%]	43% [30%, 57%]	42% [39%, 45%]	43% [32%, 53%]
West	20% [18%, 23%]	21% [18%, 23%]	14% [6%, 22%]	20% [18%, 23%]	14% [6%, 22%]	20% [18%, 23%]	15% [5%, 25%]	21% [19%, 24%]	8.6% [4%, 13%]
Self-reported health status									
Excellent/Very good	69% [66%, 71%]	72% [69%, 74%]	21% [12%, 30%]	70% [67%, 72%]	26% [11%, 41%]	70% [68%, 73%]	15% [6%, 24%]	71% [68%, 73%]	37% [28%, 46%]
Good	22% [20%, 25%]	22% [20%, 24%]	31% [21%, 40%]	22% [20%, 25%]	26% [13%, 39%]	22% [20%, 24%]	35% [23%, 47%]	22% [19%, 24%]	33% [23%, 42%]
Fair/Poor	9.1% [8%, 11%]	6.6% [5%, 8%]	48% [37%, 60%]	8% [7%, 10%]	48% [32%, 64%]	7.6% [6%, 9%]	50% [37%, 63%]	7.5% [6%, 9%]	30% [20%, 41%]
Hypertension status									
No	68% [65%, 70%]	71% [69%, 73%]	17% [9%, 24%]	69% [67%, 71%]	21% [9%, 34%]	69% [67%, 72%]	26% [14%, 38%]	70% [68%, 73%]	36% [27%, 46%]

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TABLE 1 | (Continued)

Characteristics, %	Total $N = 2177$	Coronary heart disease: No $n = 2044$ [94.1%]	Coronary heart disease: Yes $n = 133$ [5.9%]	Angina: No $n = 2115$ [97.4%]	Angina: Yes $n = 62$ [2.6%]	MI/heart attack: No $n = 2092$ [96.5%]	MI/heart attack: Yes $n = 85$ [3.5%]	Other heart disease: No $n = 2,025$ [93.2%]	Other heart disease: Yes $n = 152$ [6.8%]
Yes	32% [30%, 35%]	29% [27%, 31%]	83% [76%, 91%]	31% [29%, 33%]	79% [66%, 91%]	31% [28%, 33%]	74% [62%, 86%]	30% [27%, 32%]	64% [54%, 73%]
Diabetes status									
No Diabetes	89% [87%, 90%]	90% [89%, 92%]	62% [52%, 73%]	90% [88%, 91%]	55% [39%, 71%]	90% [88%, 91%]	61% [48%, 74%]	89% [88%, 91%]	78% [71%, 86%]
Diabetes or prediabetes	11% [10%, 13%]	10% [8%, 11%]	38% [27%, 48%]	10% [9%, 12%]	45% [29%, 61%]	10% [9%, 12%]	39% [26%, 52%]	11% [9%, 12%]	22% [14%, 29%]
Smoking status									
Never smoker	63% [60%, 66%]	64% [62%, 67%]	40% [28%, 52%]	64% [61%, 67%]	26% [14%, 38%]	64% [61%, 66%]	38% [25%, 51%]	64% [61%, 67%]	51% [40%, 61%]
Former smoker	25% [22%, 27%]	23% [21%, 26%]	45% [33%, 56%]	24% [22%, 26%]	52% [36%, 67%]	24% [22%, 26%]	41% [28%, 54%]	24% [21%, 26%]	38% [28%, 47%]
Current smoker	12% [11%, 14%]	12% [10%, 14%]	16% [8%, 24%]	12% [10%, 14%]	23% [8%, 37%]	12% [10%, 14%]	21% [10%, 31%]	12% [11%, 14%]	12% [6%, 17%]
Physical activity[d]									
Sufficient physical activity	81% [79%, 83%]	83% [81%, 85%]	60% [49%, 71%]	82% [80%, 84%]	51% [36%, 67%]	82% [80%, 84%]	60% [46%, 73%]	82% [80%, 84%]	76% [68%, 84%]
No or insufficient physical activity	19% [17%, 21%]	17% [15%, 19%]	40% [29%, 51%]	18% [16%, 20%]	49% [33%, 64%]	18% [16%, 20%]	40% [27%, 54%]	18% [16%, 20%]	24% [16%, 32%]
Alcohol consumption									
Lifetime abstainer	10% [9%, 12%]	10% [9%, 12%]	11% [4%, 17%]	10% [9%, 12%]	14% [3%, 26%]	10% [8%, 12%]	18% [7%, 29%]	11% [9%, 13%]	7% [2%, 10%]
Former infrequent drinker	13% [11%, 15%]	12% [11%, 14%]	25% [15%, 34%]	13% [11%, 14%]	35% [19%, 51%]	13% [11%, 15%]	22% [12%, 32%]	13% [11%, 15%]	18% [11%, 26%]
Current drinker	76% [74%, 79%]	77% [75%, 79%]	65% [54%, 76%]	77% [75%, 79%]	50% [34%, 66%]	77% [75%, 79%]	60% [48%, 73%]	76% [74%, 79%]	75% [67%, 84%]

[a]Law enforcement workers include bailiffs, correctional officers, and jailers; detectives and criminal investigators; fish and game wardens; parking enforcement workers; police and sheriff's patrol officers and transit and railroad police.
[b]Racial-ethnic minorities including Asian ($N = 24$), American Indian/Alaska Native ($N = 14$), Hispanic/Latino ($N = 272$), non-Hispanic black ($N = 409$) and other or multiple racial groups ($N = 27$) were aggregated because the limited sample size and proportion of participants reporting CVD in these groups impacted coefficients of variation and prevalence estimates.
[c]Sample characteristics were weighted.
[d]Physical activity defined as no or insufficient (no exercise/< 150 min light-to-moderate/< 75 min vigorous physical activity and sufficient (≥ 150 min light-to-moderate/≥ 75 min vigorous physical activity.

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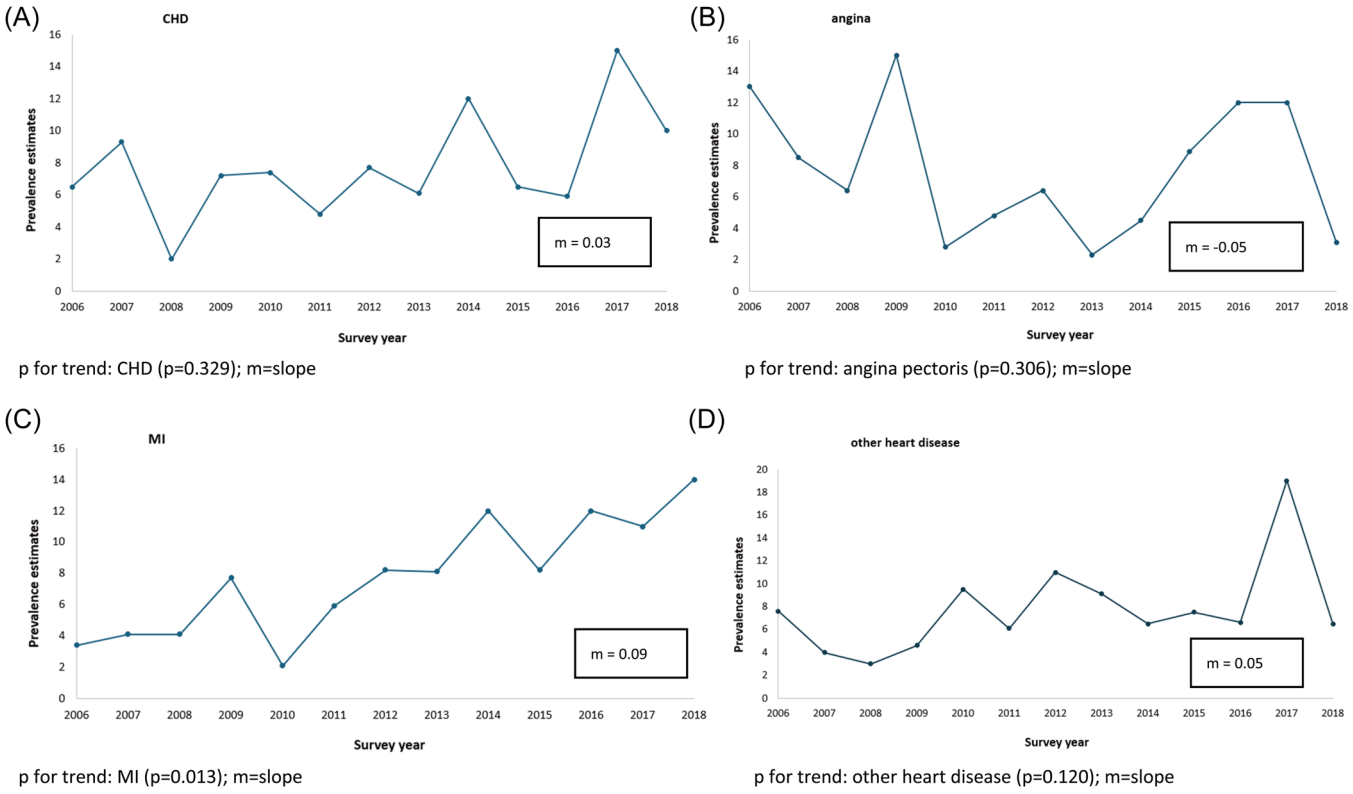

FIGURE 2 | Temporal trends in the prevalence of cardiovascular disease among law enforcement workers: the National Health Interview Survey, 2006–2018. (A) Temporal trends in the prevalence of CHD. (B) Temporal trends in the prevalence of Angina. (C) Temporal trends in the prevalence of MI/heart attack. (D) Temporal trends in the prevalence of Other heart disease. *p* for trend: CHD ($p = 0.329$); $m =$ slope *p* for trend: angina pectoris ($p = 0.306$); m = slope. *p* for trend: MI ($p = 0.013$); $m =$ slope *p* for trend: other heart disease ($p = 0.120$); $m =$ slope.

departments with 1–24 employees. Prevalence also differed by CVD outcomes for employer type, employee tenure and compensation type (Table 2). For example, federal or state employees demonstrated higher prevalence of angina and prevalence increased with the number of years employed in law enforcement across CVD outcomes (Table 2).

3.4 | Associations of Employment Factors With Prevalence of CVD Outcomes in Law Enforcement Workers

Table 3 presents the adjusted odds ratio ([OR] 95% CI) for associations between employment factors and the prevalence of CVD outcomes in law enforcement workers. When compared to currently employed law enforcement workers, disabled workers had significantly higher prevalence odds for all CVD outcomes while retired workers demonstrated higher prevalence odds for all CVD outcomes, significant for angina, MI and aggregated CVD (Table 3). Compared to those in departments with 100–499 employees, law enforcement workers employed in smaller departments (1–24 employees) had significantly higher prevalence odds of CHD (OR = 3.99; 95% CI: 1.91, 8.35), MI (OR = 3.62; 95% CI: 1.71, 7.69), other heart disease (OR = 1.86; 95% CI: 1.00, 3.44) and aggregated CVD (Table 3). Likewise, compared to those in departments with 100–499 employees, law enforcement workers in departments with 25–99 employees had significantly higher prevalence odds of MI while those in departments with 500 or more employees demonstrated significantly higher prevalence odds of both MI and other heart disease (Table 3).

In addition, after controlling for age and other key factors, the prevalence odds of CHD (OR = 2.58; 95% CI: 1.20, 5.57) was higher among law enforcement workers employed for 20 or more years compared to those with tenures below 10 years, while those with tenures between 10 and 19 years demonstrated nonsignificant higher prevalence odds across all CVD outcomes (Table 3). Local government employees compared to federal or state government employees demonstrated higher prevalence odds of angina while hourly paid law enforcement workers had higher prevalence odds of CHD, angina and MI but results were not statistically significant (Table 3). Adjusting for select mediators attenuated estimates but did not alter the overall associations between employment factors and prevalence of CVD outcomes (Supporting Information S1: Table SI).

4 | Discussion

The primary objective of our study was to evaluate trends in the prevalence of CVD outcomes in law enforcement workers as well as associations of select employment factors with prevalent CVD to inform direction for future research, surveillance, and

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TABLE 2 | Occupational characteristics and prevalence [95% CI] of cardiovascular disease in law enforcement workers[a]: the National Health Interview Survey—2006–2018 ($N = 2177$)[b].

	Coronary heart disease			Angina		MI/heart attack		Other heart disease	
	Total	No	Yes	No	Yes	No	Yes	No	Yes
Characteristics, %	**$N = 2177$**	**$n = 2044$ [94.1%]**	**$n = 133$ [5.9%]**	**$n = 2115$ [97.4%]**	**$n = 62$ [2.6%]**	**$n = 2092$ [96.5%]**	**$n = 85$ [3.5%]**	**$n = 2025$ [93.2%]**	**$n = 152$ [6.8%]**
Labor force participation									
Retired	20% [18%, 22%]	18% [16%, 20%]	58% [46%, 70%]	19% [17%, 21%]	61% [47%, 76%]	19% [17%, 21%]	53% [40%, 66%]	19% [16%, 21%]	41% [31%, 51%]
Disabled	2.9% [2%, 4%]	2.2% [2%, 3%]	14% [6%, 21%]	2.5% [2%, 3%]	18% [7%, 29%]	2.5% [2%, 3%]	15% [5%, 24%]	2.4% [2%, 3%]	10% [4%, 16%]
Currently working	77% [75%, 79%]	80% [78%, 82%]	28% [16%, 40%]	78% [76%, 81%]	21% [9%, 33%]	79% [76%, 81%]	32% [20%, 44%]	79% [77%, 81%]	49% [38%, 60%]
Employee type									
Federal or state government	43% [40%, 46%]	43% [40%, 46%]	43% [31%, 54%]	42% [39%, 45%]	55% [40%, 71%]	42% [39%, 46%]	45% [32%, 58%]	43% [40%, 46%]	41% [30%, 51%]
Local government	57% [54%, 60%]	57% [54%, 60%]	57% [46%, 69%]	58% [55%, 61%]	45% [29%, 60%]	58% [54%, 61%]	55% [42%, 68%]	57% [54%, 60%]	59% [49%, 70%]
Department/workforce size									
1–24 employees	14% [12%, 16%]	13% [11%, 15%]	30% [19%, 41%]	14% [12%, 16%]	19% [7%, 32%]	13% [11%, 15%]	26% [15%, 38%]	13% [11%, 15%]	20% [10%, 30%]
25–99 employees	25% [23%, 27%]	25% [23%, 27%]	24% [15%, 33%]	25% [23%, 27%]	24% [10%, 39%]	25% [23%, 27%]	29% [17%, 42%]	25% [23%, 28%]	21% [14%, 29%]
100–499 employees	36% [33%, 39%]	37% [34%, 39%]	24% [15%, 33%]	36% [33%, 39%]	33% [18%, 48%]	37% [34%, 39%]	19% [10%, 28%]	37% [34%, 39%]	27% [18%, 36%]
500 employees or more	25% [23%, 28%]	25% [23%, 28%]	22% [14%, 31%]	25% [23%, 28%]	23% [11%, 36%]	25% [23%, 28%]	26% [15%, 37%]	25% [22%, 27%]	31% [22%, 40%]
Employee tenure; mean [95% CI]	12.8 [12.28, 13.33]	12.3 [11.77, 12.85]	20.6 [19.09, 22.11]	12.7 [12.16, 13.23]	16.9 [14.12, 19.67]	12.6 [12.06, 13.14]	18.3 [15.92, 20.76]	12.5 [11.95, 13.04]	17.0 [15.17, 18.85]
< 10 years	43% [40%, 46%]	45% [42%, 48%]	14% [7%, 21%]	44% [41%, 46%]	24% [11%, 38%]	44% [41%, 47%]	22% [10%, 33%]	44% [42%, 47%]	25% [17%, 33%]
10–19 years	29% [27%, 32%]	30% [27%, 32%]	24% [15%, 34%]	29% [27%, 32%]	40% [24%, 56%]	29% [27%, 32%]	31% [19%, 44%]	29% [27%, 32%]	30% [21%, 39%]
20+ years	27% [25%, 30%]	25% [23%, 28%]	62% [52%, 72%]	27% [25%, 30%]	36% [21%, 50%]	27% [24%, 29%]	47% [34%, 60%]	26% [24%, 29%]	45% [35%, 55%]

(Continues)

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TABLE 2 | (Continued)

Characteristics, %	Total	Coronary heart disease		Angina		MI/heart attack		Other heart disease	
		No	Yes	No	Yes	No	Yes	No	Yes
		$n = 2044$	$n = 133$	$n = 2115$	$n = 62$	$n = 2092$	$n = 85$	$n = 2025$	$n = 152$
	$N = 2177$	[94.1%]	[5.9%]	[97.4%]	[2.6%]	[96.5%]	[3.5%]	[93.2%]	[6.8%]
Paid by the hour									
Yes	57% [54%, 60%]	57% [54%, 60%]	54% [43%, 65%]	57% [54%, 59%]	59% [44%, 74%]	57% [54%, 60%]	55% [42%, 68%]	57% [55%, 60%]	52% [41%, 63%]
No	43% [40%, 46%]	43% [40%, 46%]	46% [35%, 57%]	43% [41%, 46%]	41% [26%, 56%]	43% [40%, 46%]	45% [32%, 58%]	43% [40%, 45%]	48% [37%, 59%]

[a]Law enforcement workers includes bailiffs, correctional officers, and jailers; detectives and criminal investigators; fish and game wardens; parking enforcement workers; police and sheriff's patrol officers and transit and railroad police.
[b]Sample characteristics were weighted.

public health planning among US law enforcement workers. Prevalence of CVD outcomes differed by sex, education, non-Hispanic white ethnicity and across traditional CVD risk factors. We observed a significant increase in the trend of prevalent MI which was different in law enforcement workers compared to active nonprotective service workers. Findings also differed by CVD outcome in the multivariable analysis. Overall, we found higher prevalence odds for CVD in law enforcement workers who (1) were disabled and retired, (2) were working in smaller (1–24 employees) and larger (500 or more employees) departments and (3) had tenure above 20 years. Although findings were not significant, tenure between 10 and 19 years, local government employees and hourly paid law enforcement workers demonstrated higher prevalence odds across select CVD outcomes.

The overall prevalence estimate of CHD in our study was similar to a study of US adults 18 years of age and older using the Behavioral Risk Factor Surveillance System from 2011 to 2018 [49]. We also observed increasing trend in prevalent MI among law enforcement workers which differed when compared to active nonprotective service workers. In contrast, declining trends in MI have been demonstrated in prior studies conducted in the general population [50, 51]; necessitating future studies that address factors involved in the increasing trend of prevalent MI in law enforcement workers. Prevalence and employment factors associated with CVD in law enforcement workers varied by CVD outcome. CHD manifests as plaque buildup in the coronary arteries occurring through multiple pathways which can result in heart attacks or MI [4, 5]. Angina, however, is a precursor of severe CVD presenting as chest pain due to decreased blood flow to cardiac muscles [3]. While the pathophysiology of CVD outcomes are distinct, pathways through which employment factors impact the development of various CVD outcomes are not fully understood and requires additional investigation.

Our findings of higher prevalence of all CVD outcomes in retired and disabled workers are consistent with some prior studies that observed "healthy worker effects" in this group given that a diagnosis of CVD may be attributed to employment resulting in law enforcement workers retiring or receiving disability benefits [20, 25, 31]. While full-time employment is associated with ongoing workplace stress and job strain, it is also linked to health benefits through several mechanisms including economic stability, access to healthcare, and perceived social and occupational status [8–10, 20, 25]. We also found that law enforcement workers in smaller and larger departments with 1–24 employees or 500 or more employees, respectively had higher prevalence of CVD outcomes including CHD, MI and other heart disease. While the current findings are novel in relation to CVD, prior studies have linked department size to stress with law enforcement workers in medium-sized and larger-sized departments demonstrating greater stress related to administrative and organizational pressure, inadequate support, physical, and psychological threats.

On the other hand, smaller departments may have workplace policies and community support systems that may alleviate stress. However, they often lack the resources and staffing necessary for emergency response operations and access to

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TABLE 3 | Multivariable models (OR [95% CI]) evaluating associations between occupational factors and prevalent CVD in law enforcement workers[a]: the National Health Interview Survey—2006–2018 ($N = 2177$).

Occupational factors	Coronary heart disease OR (95% CI)	Angina OR (95% CI)	MI/heart attack OR (95% CI)	Other heart disease OR (95% CI)	CVD[b] OR (95% CI)
Labor force participation					
Retired versus currently working	1.88 [0.83, 4.27]	5.22 [1.72, 15.88]**	2.68 [0.91, 7.88]*	1.24 [0.62, 2.50]	2.14 [1.18, 3.88]**
Disabled versus currently working	8.20 [3.10, 21.67]**	8.61 [2.43, 30.56]**	6.66 [2.16, 20.55]**	4.22 [1.87, 9.55]**	5.37 [2.53, 11.38]**
Employee type					
Local versus federal or state employee	1.03 [0.61, 1.74]	1.69 [0.90, 3.18]	1.01 [0.56, 1.85]	0.85 [0.52, 1.38]	0.97 [0.66, 1.44]
Department/workforce size					
1–24 employees versus 100–499 employees	3.99 [1.91, 8.35]**	1.16 [0.49, 2.78]	3.62 [1.71, 7.69]**	1.86 [1.00, 3.44]**	2.08 [1.21, 3.58]**
25–99 employees versus 100–499 employees	1.29 [0.65, 2.57]	0.85 [0.34, 2.11]	2.21 [1.00, 4.89]**	0.97 [0.54, 1.72]	1.07 [0.65,1.75]
500 or more employees versus 100–499 employees	1.63 [0.80, 3.31]	0.97 [0.41, 2.30]	2.10 [0.92, 4.81]*	1.89 [1.10, 3.25]**	1.49 [0.92, 2.41]
Employee tenure					
10–19 years versus below 10 years	1.76 [0.80, 3.91]	1.32 [0.63, 2.79]	1.41 [0.60, 3.32]	1.31 [0.78, 2.19]	1.30 [0.86, 1.98]
20 or more years versus below 10 years	2.58 [1.20, 5.57]**	0.47 [0.17, 1.29]	1.05 [0.44, 2.54]	1.27 [0.66, 2.45]	1.28 [0.74, 2.22]
Paid by the hour					
Yes versus no	1.34 [0.83, 2.17]	1.35 [0.74, 2.48]	1.21 [0.69, 2.11]	0.94 [0.59, 1.49]	1.18 [0.79, 1.75]

Note: Models adjusted for survey cycle, age, sex, insurance status, race/ethnicity, body mass index, smoking status, physical activity and alcohol consumption status.

[a]Law enforcement workers includes bailiffs, correctional officers, and jailers; detectives and criminal investigators; fish and game wardens; parking enforcement workers; police and sheriff's patrol officers and transit and railroad police.

[b]CVD: (no self-reported CVD outcome [coronary heart disease or angina or MI/heart attack or other heart disease] versus one or more self-reported CVD outcome).

** $p < 0.05$; * $p < 0.10$.

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health care and preventive services available to medium and larger departments. Notably, our study found that the proportion of law enforcement workers with private health insurance increased with department size. Smaller departments had a higher proportion of older aged employees and greater prevalence of obesity, hypertension, diabetes, smoking, poor health status and physical inactivity. Traditional risk factors of CVD did not substantially differ across midsize and larger departments. It is important to note that department size in our study may also represent urbanicity, with smaller departments typically operating in rural areas and medium to larger departments in urban areas. The NHIS did not collect data on urbanicity, preventing us from examining how urbanicity might influence the relationship between employment factors and CVD. Future studies are needed to explore these pathways, as employment factors, crime rates, suicide, loneliness, and workplace stress may vary with urbanicity.

Consistent with our findings, previous studies of both the general population and law enforcement workers have demonstrated that hourly pay and tenure are associated with CVD, even after adjusting for age and other key risk factors [9, 30, 31, 37]. Law enforcement workers with long tenure are exposed to chronic job stress while those on hourly pay may endure financial stress and job insecurity due to fluctuating hours and income, often necessitating multiple jobs and longer hours to maintain financial stability. Compensation type also impacts employment benefits and access to healthcare and preventive services [9, 30, 41]. Taken together, the positive relationship of tenure and compensation with CVD may be mediated through pathways of job strain and workplace stress [40, 41, 51]; since chronic exposure to stressful experiences can induce pathophysiological changes in the cardiovascular system increasing the risk of CVD [51]. Additionally, law enforcement workers employed in local or municipal governments showed a nonsignificant increase in prevalent CVD, a finding not systematically explored in previous research. Local or municipal law enforcement workers might experience higher job strain and organizational issues related to budget constraints, staffing, and compensation. Varying interactions with crime victims, types of case load and crime, and emergency response duties between local and state or federal law enforcement workers could also contribute to these findings and warrant further investigation in future studies.

Our study has some limitations. First, the NHIS utilized self-reported physician or healthcare professional diagnoses of CVD outcomes and selected risk factors, which may be impacted by recall bias, access to health care and the participants' knowledge of their health condition. This requires future studies that obtain objective clinical measures and utilize International Classification of Diseases, Clinical Modification (ICD-CM) diagnostic codes to evaluate CVD outcomes and selected risk factors. Second, despite pooling multiple years of NHIS data to increase precision of estimates and analytical sample, our focus on law enforcement workers and the low prevalence of CVD in this population limited sample size and further subgroup analysis for the present study. Third, given that we conducted secondary data analysis, we are limited by data aggregation and availability of employment and clinical factors in NHIS. We could not evaluate whether associations between employment factors and prevalent CVD differed across the very disparate subgroups of law enforcement workers which include police/sheriff, correctional officers, game wardens and parking enforcement personnel. Groups within the law enforcement have disparate employment tasks, working conditions and stressors which may impact CVD development. However, more detailed employment data were not available in the NHIS survey. Obtaining information that distinguishes subgroups of law enforcement workers at a national scale will help drive future research and will better elucidate the impact of employment on CVD and other diseases in this group. Data on psychosocial and workplace stress, noise exposure, shift work, and rates of hourly wage were not evaluated in the present analysis since they were not uniformly collected across the NHIS cycles utilized in our study. Fourth, despite the inclusion of a wide range of confounders, there may be residual confounding from unobserved variables including workplace stressors and social support, diet, dyslipidemia, occupational physical activity, shift work, long working hours and organizational justice. Fifth, the cross-sectional design of NHIS precludes inference on causality since we cannot determine whether the selected employment factors and covariates preceded the development of CVD. Sixth, while we were interested in evaluating whether associations of employment factors with prevalent CVD in law enforcement workers were modified by region, we were limited by sample size and could not conduct stratified analysis within regional subgroups.

Despite the stated limitations, our study also has notable strengths. We provide a national snapshot of both employment and traditional risk factors of CVD among law enforcement workers addressing existing gaps in occupational research by detailing novel insights into the relationship of employee size and type, hourly pay and labor force participation with prevalent CVD in a nationally representative sample of US law enforcement workers. Our study aligns with NIOSH strategic goals of identifying employment and known risk factors of CVD in law enforcement workers. We also pooled 13 years of data to increase statistical power and precision of estimates and adjusted for a wide range of potential confounders on the relationship of employment factors with CVD.

5 | Conclusion

Our study demonstrated that select employment factors some of which have not been previously evaluated in the literature were associated with prevalent CVD in law enforcement workers. We provide evidence for future studies to elucidate pathways through which law enforcement department size and type, and compensation practices may impact CVD. We also identified subgroups of law enforcement workers including those who were retired or disabled who will benefit from targeted interventions and health promotion tools that address CVD and improve CVH. Future work should focus on specific subgroups of law enforcement personnel and integrate additional employment factors, objective clinical measures of CVD, and selected risk factors and surveillance systems to more clearly elucidate how employment factors and interventions in the workplace impacts the development of CVD among law enforcement workers.

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Author Contributions

Chibuzor Abasilim and Lee S. Friedman were involved in obtaining the pilot project funding, had full access to the NHIS data and were involved with data acquisition, conception and design, interpretation of data, drafting and revisions of the manuscript, and approval of the final version. Brett Shannon, Ogungbe Oluwabunmi, Katherine E. McCoy, and Linda Forst were involved in the interpretation of data, drafting and revisions of the manuscript, and approval of the final version.

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Disclosure by AJIM Editor of Record

John Meyer declares that he has no conflict of interest in the review and publication decision regarding this article.

Ethics Statement

A claim of exemption was approved for this project by the University of Illinois Chicago IRB (#2023-0688) because NHIS is a deidentified and publicly available database.

Conflict of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are openly available in The National Health Interview Survey at https://www.cdc.gov/nchs/nhis/index.htm.

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