Preventive Medicine 191 (2025) 108225

Contents lists available at ScienceDirect

Preventive Medicine

journal homepage: www.elsevier.com/locate/ypmed

Long working hours and cardiovascular disease mortality: Prospective evidence from the United States

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ARTICLE INFO

Keywords:
Long working hours
Cardiovascular disease
Mortality
Prospective cohort study
United States

ABSTRACT

Aims: Cardiovascular disease (CVD) is the leading cause of death in the United States (U.S.). This study aimed to explore prospective associations between long working hours with CVD mortality using a large, national study in the U.S.

Methods: Data from the Midlife in the U.S. (MIDUS) Study were used, including 4051 currently employed participants without prior experience of myocardial infarction or stroke at baseline in 1995–1996. Working hours were categorized into: <35 h/week, 35–40 h/week (reference), 41–48 h/week, 49–54 h/week, and ≥ 55 h/week. Mortality data were extracted from the National Death Index (NDI) through Spring 2021. Cox proportional hazards regression was applied to analyze the prospective associations between working hours at baseline and CVD mortality, adjusting for sociodemographic and lifestyle factors. Stratified analyses by socioeconomic status (i.e., education and financial situation) were also conducted.

Results: Long working hours (≥55 h/week) were significantly associated with increased CVD mortality (adjusted HR 1.50; 95 % CI 1.03–2.17) compared to the reference group. Subgroup analyses showed that individuals with low education level or poor financial situation had a higher risk of CVD mortality when working long hours.

Conclusion: Long working hours are a significant risk factor for CVD mortality in this national sample of U.S. workers, and participants with low socioeconomic status are more vulnerable to the effects of long working hours on CVD deaths. These findings highlight the need for considering working hour interventions in public health strategies to improve cardiovascular health outcomes in the workforce.

1. Introduction

Cardiovascular disease (CVD) is the leading cause of death both in the United States (U.S.) and globally, with 931,552 CVD-related deaths recorded in the U.S. alone (Martin et al., 2024) and over 16 million worldwide deaths from ischemic heart disease (IHD) and stroke in 2021 (Naghavi et al., 2024). Current trends indicate a marked increase of CVD incidence among young adults, as well as high and rising CVD mortality in working-age populations in the U.S. (Andersson and Vasan, 2018; Harris et al., 2021). Identifying modifiable risk factors for CVD is crucial, as various occupational factors have been implicated in the development and progression of CVD (Li et al., 2022; Schnall et al., 2016; Taouk et al., 2020). Among occupational factors, long working hours - defined by the World Health Organization (WHO) and International Labour Organization (ILO) as working more than 55 h per week - were recently identified and confirmed as a significant risk factor for CVD mortality (Pega et al., 2021, 2022). These associations have been supported by a number of epidemiologic studies conducted across various regions in Asia and Europe (Descatha et al., 2020; Li et al., 2020; Rugulies, 2024). Some recent cohort studies have also provided additional prospects. For instance, a study by Alicandro et al. in 2020 on Italian workers found that long working hours were associated with a hazard ratio (HR) of 1.98 (95 % CI: 0.87–4.52) for CVD mortality in women (Alicandro et al., 2020). Another cohort study by Eng et al. reported an increase in IHD

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https://doi.org/10.1016/j.ypmed.2025.108225
Received 17 November 2024; Received in revised form 8 January 2025; Accepted 10 January 2025
Available online 11 January 2025

risk among men in New Zealand (HR 1.04; 95 % CI 0.99–1.09) (Eng et al., 2023). A multi-cohort study by Ervasti et al. in 2021 involving 103,861 individuals from Finland, Sweden, Denmark, and the UK, reported a HR of 1.68 (95 % CI 1.08–2.61) for CVD mortality among workers exposed to long working hours. However, while much of the evidence relating long working hours with CVD mortality risk was generated in European and Asian countries, there a severe lack of cohort studies specifically addressing this association in the U.S., presenting a critical research gap. Across a total of nine studies assessing long working hours and risk of CVD in U.S. populations, results were inconsistent and data were relatively old and severely limited (i.e., baselines ranging from 1973 to 1975 and the latest follow-up expiring prior to 2008) (Arnold, 1985; Berkman and Breslow, 1983; Hauser and Sewell, 1985; House et al., 2005; Madans et al., 1986; McGwin, 2005; Russek and Zohman, 1958; Sewell and Hauser, 1975; Thiel et al., 1973); or with case-control designs, small sample sizes, and inadequate adjustment for potential confounders (McGwin, 2005; Russek and Zohman, 1958; Thiel et al., 1973).

Furthermore, while prior research evidence has elucidated a prominent role of socioeconomic status (SES) in moderating relationships between working conditions and health, there is a lack of scientific consensus regarding the role of SES in long working hours and CVD (Hoven and Siegrist, 2013). A systematic review and meta-analysis published in 2015 demonstrated SES-dependent associations between long working hours and CVD, with elevated risk observed for participants in low SES compared to intermediate and high SES groups (Kivimäki et al., 2015). Recent systematic reviews conducted by the WHO/ILO did not fully support the hypothesis of effect modification by SES (Descatha et al., 2020; Li et al., 2020).

Building on these knowledge gaps, our study focuses on examining associations of long working hours and CVD mortality within the U.S. population using data from the Midlife in the U.S. (MIDUS) study, which spans a follow-up period of 26 years. We applied prospective cohort design to provide insights specific to the U.S. To better clarify previous inconsistent findings regarding SES in associations between long working hours and CVD, we conducted subgroup analyses based on education and financial situation. Therefore, the objective of this study is two-fold: to investigate the prospective associations between working hours and CVD mortality, and to explore potential effect modification by SES.

2. Methods

2.1. Study participants

Data for this study were extracted from the MIDUS I survey, initiated in 1995–1996. This national longitudinal study investigates psychological, social, behavioral, and health factors among non-institutionalized, English-speaking U.S. adults aged 25–74, with data collected via phone interviews supplemented by self-administered questionnaires (Brim et al., 2019). The MIDUS I core sample was a national probability sample of American adults aged 24–74, selected via Random Digit Dialing (RDD) from working telephone banks in the 48 contiguous United States, and additional participants included siblings of the RDD respondents identified through a national household screening project and a twin database. The MIDUS I study ultimately had a total participation of 7108 individuals with a response rate of 70 % (Radler, 2014). Given the comprehensive sampling procedure of the MIDUS I survey, a broadly representative sample of the U.S. working population was yielded by restricting to those who were currently working at baseline in our study.

Our study restricted the sample to individuals currently employed at baseline, totaling 4297 participants in MIDUS I. Individuals who had previously experienced myocardial infarction or stroke before MIDUS I ($N = 30$), or were missing data on reporting weekly working hours and other covariates ($N = 216$), were excluded. The flowchart detailing the process of participant selection is shown in Fig. 1. Ultimately, we included 4051 eligible individuals in the study. The study protocol was approved by the University of California, Los Angeles Institutional Review Board (IRB#22–000604).

2.2. Measures

Weekly working hours were total working hours for main job and other job(s), which were categorized into 5 groups: <35 h/week, 35 to 40 h/week (reference category), 41 to 48 h/ week, 49 to 54 h/week, and ≥ 55 h/week, according to the standardized WHO/ILO definition (Descatha et al., 2020; Li et al., 2020). The reference group (35–40 h/ week) was chosen to represent a standard working hours worldwide which has been applied by the prior WHO/ILO research projects (Descatha et al., 2020; Li et al., 2020; Pega et al., 2021).

The health outcome of our study is CVD mortality. CVD mortality data through Spring 2021 were sourced from a dataset linked to the National Death Index (NDI) via combinations of personal information including name, birth date, sex, and social security number, with details including decedent status, death timing, and causes of death with the International Classification of Diseases (ICD) codes (Ryff et al., 2023). CVD-related deaths were identified using ICD-9 codes 390–459 and ICD-10 codes I00-I99, with IHD mortality cases defined using ICD-9 code 410–414 and ICD-10 codes I21–25. The follow-up time was defined as beginning at the MIDUS I survey, with censoring of CVD death events occurring thereafter.

Demographic factors were included as covariates, such as sex (male, female), age (continuous variable), race (White, non-White), marital status (married, never married, Divorced/widowed/separated). Two indicators of SES were used in this study, including educational

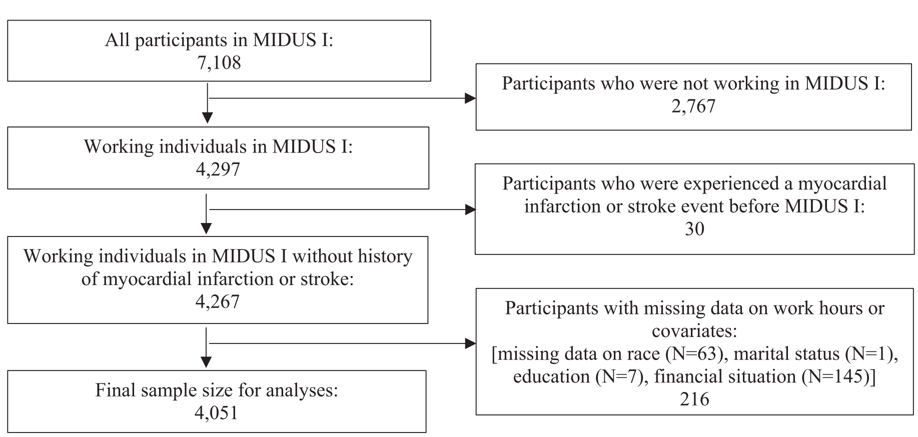

Fig. 1. Sample size selection flowchart for the analysis of working hours at baseline (1995–1996) and cardiovascular disease mortality through 2021 among adults in the United States.

attainment (participants with education achievement lower than "1 to 2 years of college but no degree" as low education; others are high education), and financial situation (participants who rated their current financial situation lower than 6 on an 0–10 scale as poor financial situation; others as good financial situation. This scale did not correspond directly to a specific U.S. dollar amount of individual salary but rather captured subjective financial well-being, and study sample were dichotomized into two groups with similar sample sizes to maximize statistical power for analyses). Behavior factors were also considered: alcohol consumption (heavy drinking, non-heavy drinking. Participants who used three times or more amounts of alcohol than they intended during the past 12 months were defined as heavy drinker), smoking status (smoker, non-smoker. Smoker was defined as self-reported regularly smoking currently), and leisure-time physical activity (active exercise, inactive exercise. Active exercise was defined as several times a week or more engaging in vigorous physical activity in summer and winter). All these approaches have been applied in previous MIDUS publications (Choi, 2018; Hakulinen and Jokela, 2019; Matthews et al., 2021, 2023).

2.3. Statistical analyses

First, descriptive statistics and relative frequencies were conducted to assess the baseline characteristics of the sample by working hours. Differences across working hours groups were compared by analysis of variance (for continuous variables) and chi-squared test (for categorical variables). The prospective associations of working hours at baseline with CVD mortality risk were analyzed using Cox proportional hazards regression, reporting hazard ratios (HRs) with 95 % confidence intervals (CIs). Calendar time was used as the time scale of the Cox proportional hazards models for calculating length of follow-up in terms of person-years, and participants were right-censored at the end of follow-up (up to Spring 2021) or the event time of CVD-related death, depending on whichever came first. Multivariable regression models were fitted, adjusting for age, sex, race, marital status, educational attainment, financial situation, alcohol consumption, smoking status, and leisure-time physical activity. To investigate potential effect modification by SES, we conducted multiplicative interaction analyses between working hours and SES indicators, specifically educational attainment and financial situation levels. Significant interaction terms between working hours and both SES indicators were observed ($p < 0.05$). Consequently, we stratified participants by educational attainment and financial situation and then estimated associations of long working hours with CVD mortality within each SES stratum. We also conducted a series of sensitivity analyses to augment our methodology of outcome assessment. We performed analyses removing CVD death cases within the first three years of follow-up to minimize potential reverse causality, where health conditions may have influenced exposure to long working hours. Similarly, we tested the exclusion of CVD death cases from 2020 onwards to account for impacts of the COVID-19 pandemic. Finally, we expanded analyses to examine further mortality outcomes, including IHD and all-cause mortality. All statistical analyses were conducted using SAS version 9.4 (SAS Institute Inc., Cary, North Carolina).

3. Results

Table 1 presents the distribution of demographic and lifestyle characteristics across different working hour groups. The study sample consisted of 4051 participants, with 20.8 % reporting long working hours. The gender distribution was generally balanced. The majority of participants were middle-aged, with a mean age of 43.7 years. Most participants were white (>90 %) and married (nearly two thirds). Statistically significant differences were observed across working hour categories in terms of sex, age, race, marital status, education level, and physical activity. For instance, among participants reporting long working hours (≥55 h/week), they were more likely to be males, younger, White, with high education, and physically inactive.

There were 213 CVD deaths over 98,133 person-years, resulting in an

Table 1
Baseline characteristics of adults in the United States by working hours (MIDUS I study, 1995–1996 (N = 4051).

Variables	All	Working hours (hours/week)					*p*
		<35 (*N* = 592)	35–40 (*N* = 1440)	41–48 (*N* = 642)	49–54 (*N* = 534)	≥ 55 (*N* = 843)	
Sex (N, %)							<0.0001
Male	2124 (52.4)	152 (7.2)	613 (28.9)	364 (17.1)	361 (17.0)	634 (29.9)	
Female	1927 (47.6)	440 (22.8)	827 (42.9)	278 (14.4)	173 (9.0)	209 (10.9)	
Age (mean, SD)							<0.0001
	43.7 (10.9)	46.9 (12.8)	43.8 (11.0)	42.2 (9.9)	43.0 (10.0)	43.0 (10.0)	
Race (N, %)							0.0178
White	3705 (91.5)	545 (14.7)	1289 (34.8)	590 (15.9)	499 (13.5)	782 (21.1)	
Non-white	346 (8.5)	47 (13.6)	151 (43.6)	52 (15.0)	35 (10.1)	61 (17.6)	
Marital status (N, %)							0.0001
Married	2788 (68.8)	434 (15.6)	932 (33.4)	437 (15.7)	364 (13.1)	621 (22.3)	
Never married	504 (12.4)	55 (10.9)	194 (38.5)	92 (18.3)	73 (14.5)	90 (17.9)	
Divorced/widowed/separated	759 (18.7)	103 (13.6)	314 (41.4)	113 (14.9)	97 (12.8)	132 (17.4)	
Education (N, %)							<0.0001
Low education	2057 (50.8)	334 (16.2)	797 (38.8)	305 (14.8)	217 (10.6)	404 (19.6)	
High education	1994 (49.2)	258 (12.9)	643 (32.3)	337 (16.9)	317 (15.9)	439 (22.0)	
Financial situation (N, %)							0.0528
Poor	1944 (48.0)	293 (15.1)	724 (37.2)	296 (15.2)	231 (11.9)	400 (20.6)	
Good	2107 (52.0)	299 (14.2)	716 (34.0)	346 (16.4)	303 (14.4)	443 (21.0)	
Alcohol (N, %)							0.1772
Heavy drinker	433 (10.7)	51 (11.8)	149 (34.4)	69 (15.9)	70 (16.2)	94 (21.7)	
Non-heavy drinker	3618 (89.3)	541 (15.0)	1291 (35.7)	573 (15.8)	464 (12.8)	749 (20.7)	
Smoking (N, %)							0.0788
Smoker	885 (21.9)	107 (12.1)	341 (38.5)	139 (15.7)	110 (12.4)	188 (21.2)	
Non-smoker	3166 (78.1)	485 (15.3)	1099 (34.7)	503 (15.9)	419 (13.4)	655 (20.7)	
Physical activity (N, %)							<0.0001
Inactive	2767 (68.3)	381 (13.8)	928 (33.5)	453 (16.4)	383 (13.8)	622 (22.5)	
Active	1284 (31.7)	211 (16.4)	512 (39.9)	189 (14.7)	151 (11.8)	221 (17.2)	

P-values indicate results of comparisons across working hours groups, with differences determined by analysis of variance (for continuous variable) and chi-squared test (for categorical variables).

overall CVD mortality rate of 2.17 per 1000 person-years. Table 2 presents the HRs from the Cox proportional hazard regression analyses, examining associations between working hours at baseline and CVD mortality. The crude hazard ratio (cHR) for long working hours (≥55 h/week) was 1.47 (95 % CI: 1.03–2.10), showing a significant association with a higher risk of CVD mortality. After adjusting for age, sex, race, marital status, education, financial situation, alcohol consumption, smoking status, and physical activity, the adjusted hazard ratio (aHR) remained significant at 1.50 (95 % CI: 1.03–2.17). While short working hours (<35 h/week) were associated with a higher risk of CVD mortality in the crude model by 86 %, significance was attenuated in the fully adjusted model. Further details of the fully adjusted model are presented in Supplementary Table 1.

In exploring the associations between long working hours and CVD mortality risk, we conducted subgroup analyses, stratified by education and financial situation, given the significant interactions observed between working hours and these SES indicators. These results are shown in Fig. 2. The increased risk of CVD mortality was significant among participants with low education levels and those with a poor financial situation, even after adjusting for potential confounders. Among participants with low education levels, long working hours (≥55 h/week) had a significantly higher risk of CVD mortality in both the crude model (cHR 1.69; 95 % CI 1.10–2.58) and the fully adjusted model (aHR 1.72; 95 % CI 1.10–2.70). Similarly, among participants with a poor financial situation, long working hours (≥55 h/week) showed a significantly higher risk of CVD mortality in both the crude model (HR 2.49; 95 % CI 1.45–4.26) and the adjusted model (aHR 2.66; 95 % CI 1.51–4.67). In addition, stratified analysis by sex showed similar pattern of associations between men and women (see Supplementary Table 2).

The results of the sensitivity analyses conducted to increase the robustness of outcome assessment in associations of working hours with CVD mortality are shown in Supplementary Tables 3 and 4. While none of the results attained statistical significance in the fully adjusted models, we observed a similar pattern of elevated mortality risk in participants working ≥55 h/week.

4. Discussion

In this national, population-based study of U.S. workers, we observed significant associations of long working hours (≥55 h/week) with elevated risk of CVD mortality. These results are consistent with our hypothesis and prior evidence originating outside of the U.S., which have consistently shown an association between long working hours and increased CVD mortality risk. Our findings align with the recent global burden of disease estimates from the WHO and ILO systematic reviews (Pega et al., 2021, 2022), as well as several epidemiologic studies across Asia and Europe (Alicandro et al., 2020; Descatha et al., 2020; Li et al., 2020; Rugulies, 2024). Our finding of an adjusted HR of 1.50 (95 % CI: 1.03–2.17) for CVD mortality and long working hours is also comparable to hazard estimates from international cohorts. For example, Ervasti et al. reported an HR of 1.68 (95 % CI 1.08–2.61) for CVD mortality in their multi-cohort study in Europe (Ervasti et al., 2021). Hayashi et al. reported an HR of 1.63 (95 % CI 1.01–2.63) for acute myocardial infarction in Japan (Hayashi et al., 2019). Holtermann et al. reported an HR of 1.28 (95 %CI 0.91–1.78) for IHD mortality in Copenhagen (Holtermann et al., 2010; Li et al., 2020). Interestingly, we also detected that short working hours (<35 h/week, largely represented by part-time employment) were associated with an increased CVD mortality risk (though statistical significance was not reached in the fully adjusted model), suggesting individuals with pre-existing health conditions or other limitations are more likely to engage in part-time work (see Supplementary Table 5). Such underlying health conditions may contribute to increased mortality risk, thereby leading to the observed associations of short working hours with CVD mortality (Kivimäki et al., 2015). Furthermore, the sensitivity analyses took considerations of early CVD deaths, impact of the COVID-19 pandemic, and expanded outcomes to include IHD and all-cause mortality. The results showed a consistent pattern of associations, with HRs remaining elevated among long working hours groups. Although these associations did not reach statistical significance in the fully adjusted models, the overall trends align with previous literature linking long working hours with elevated mortality risks.

Our results also clarify previous inconsistent findings regarding the relationship between long working hours and CVD in studies drawing data from U.S. populations (Arnold, 1985; Berkman and Breslow, 1983; Hauser and Sewell, 1985; House et al., 2005; Madans et al., 1986; McGwin, 2005; Russek and Zohman, 1958; Sewell and Hauser, 1975; Thiel et al., 1973).These studies utilized relatively old data, with baseline time-points ranging from 1973 to 1975, and with the latest follow-up wave expiring prior to 2008. These studies were also subject to severe methodological limitations, as they used non-fatal self-reported data for heart disease and stroke outcomes, as opposed to medically certified mortality data. They had minimal adjustment for confounders. Several of these studies had attrition rates above 20 %, raising concerns that substantial loss during follow-up may have introduced selection bias (Arnold, 1985; Berkman and Breslow, 1983; Hauser and Sewell, 1985). This confluence of factors ultimately resulted in imprecise estimates for incident heart disease and stroke risk, with wide CIs and no risk estimates for heart disease or stroke mortality. Finally, a nested case-control study spanning from 1996 to 2000 found no significant associations between IHD and extended working hours or average number of jobs (McGwin, 2005). Two case-control studies offered preliminary evidence for a role of long working hours in CVD, but these studies had small sample sizes (under 100 participants) and limited adjustment for confounders (Russek and Zohman, 1958; Thiel et al., 1973).

The physiological evidence linking long working hours with CVD indicates that the prolonged physical and mental effort associated with long working hours leads to excessive sympathetic arousal, inducing the release of stress hormones such as cortisol and adrenalin (Chandola et al., 2010). The downstream consequences of such chronic sympathetic nervous system activation are multifactorial, resulting in physiological, neuroendocrine, and immunological perturbation (Härmä et al., 2024). With extended exposure, such disruptions exceed the compensatory capacity of the autonomic and cardiovascular systems, ultimately manifesting as cardiometabolic disease conditions, including hypertension and atherosclerotic lesions (Kivimäki and Steptoe, 2018).

Our subgroup analyses provided new findings related to the SES, particularly in educational attainment and financial situation. Participants with low educational levels and poor financial situation were more vulnerable to the adverse effects of long working hours, showing significantly higher risks of CVD mortality in both crude and adjusted models. These results support the notion that the association between long working hours and CVD mortality is exacerbated in low SES groups (Kivimäki et al., 2015; Li et al., 2020), and contributes to the understanding of occupational health disparities by interrogating the role of SES as a potential effect modifier in associations of long working hours

Table 2
Prospective associations of working hours at baseline (1995–1996) with cardiovascular disease (CVD) mortality through 2021 among adults in the United States (N = 4051, CVD deaths = 213).

Working hours (hours/week)	Mortality rate (per 1000 person-years)	Crude model			Adjusted model*		
		HR	95 % CI		HR	95 % CI	
<35	3.41	1.86	1.28	2.69	1.24	0.85	1.83
35–40	1.86	1.00			1.00		
41–48	1.65	0.88	0.56	1.39	1.12	0.71	1.77
49–54	1.38	0.74	0.44	1.25	0.79	0.47	1.35
≥55	2.74	1.47	1.03	2.10	1.50	1.03	2.17

* Adjusted by age, sex, race, marital status, education, financial situation, alcohol, smoking, and physical activity.

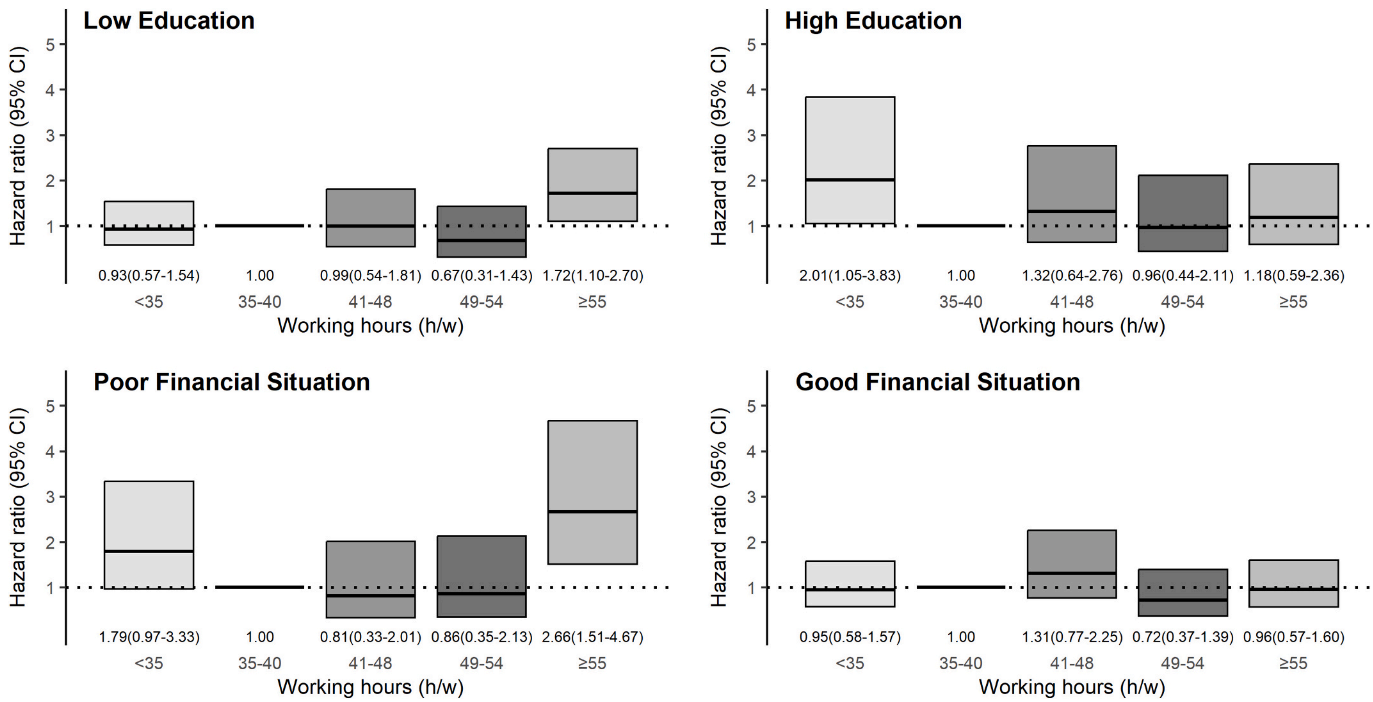

Fig. 2. Association between working hours at baseline (1995–1996) and CVD mortality through 2021 among adults in the United States, stratified by socioeconomic status (N = 4051).
Stratified analysis by education (with adjustment for age, sex, race, marital status, financial situation, alcohol, smoking, and physical activity), and by financial situation (with adjustment for age, sex, race, education, marital status, alcohol, smoking, and physical activity) (N = 4051).

with CVD mortality. A systematic review of prospective cohort studies reported substantial evidence for moderating roles of SES in participants experiencing adverse work environments in relation to health outcomes (Hoven and Siegrist, 2013). Individuals with low SES consistently exhibited greater vulnerability to strenuous working conditions across a range of physical and mental health outcomes. The impact of such work conditions may be amplified further by other factors faced by low SES groups, including limited access to resources and protective factors such as healthcare.

The major strengths of this study lie in the quality of the data and the methodological design. The large, nationally sample from the MIDUS study includes U.S. workers across a broad range of demographic, professional, and clinical characteristics, enhancing the generalizability of our findings. The health outcome of CVD mortality was based on verified empirical data from a reliable source (the National Death Index), ensuring the accuracy and robustness of our outcome measures (Ter-Minassian et al., 2023). Although the MIDUS study uses self-reported working hours, research has shown that self-reported working hours are highly consistent with objectively measured working hours, further confirming the accuracy of our exposure assessment (Imai et al., 2016). Our study is methodologically rigorous, employing comprehensive adjustments for a wide range of covariates including demographic, socioeconomic, and behavioral factors. This reduces the potential for confounding bias and increases the validity of our findings. The long follow-up period of 26 years provides a substantial observation window, allowing us to assess the long-term effects of working hours on cardiovascular health. To our knowledge, our study is the first to examine prospective associations between long working hours and CVD mortality in a U.S. population.

However, our study still has several limitations. A significant limitation of our study is that working hours were measured only at baseline, and changes in working hours during the follow-up were not considered, which may pose a risk of exposure misclassification. Additionally, although we adjusted for a number of variables, residual confounding cannot be completely ruled out. In addition, the participants were mainly white, which would limit the generalizability of our findings to more diverse populations. Lastly, while our study covers a long follow-up period, the number of sub-types of fatal CVD events was still small, for instance, only 31 cases of stroke deaths were identified in our study, thus it is challenging to interpret the potential effects of working hours on risk of cerebrovascular disease.

5. Conclusion

Our study provides robust evidence that long working hours are a significant risk factor for CVD mortality, and that low SES groups are more vulnerable to adverse health impacts from long working hours. These findings stress the importance of promoting interventions on working hour considerations into public health strategies and workplace policies. Employers and policymakers should prioritize both upstream measures, such as regulating working hours, and downstream interventions, like promoting work-life balance, stress management, and regular health screenings to mitigate the adverse health impacts of long working hours (Härmä et al., 2024). Addressing these issues is crucial for improving cardiovascular health outcomes and overall well-being among the workforce in the U.S.

Funding

The MIDUS study has been funded by the following: John D. and Catherine T. MacArthur Foundation Research Network, National Institute on Aging (P01-AG020166), and National Institute on Aging (U19-AG051426). For this analytic project, Y.G. was partially supported by a Start-Up Grant from the University of University Los Angeles (UCLA) to Dr. Li as a new faculty member; T.A.M. and J.L. were partially supported by a Research Grant from the Centers for Disease Control and Prevention (CDC) / National Institute for Occupational Safety and Health (NIOSH) (Award No.: R21OH012446, PI: J.L.). The sponsors had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the

article; and decision to submit the article for publication. The contents of this article are solely the responsibility of the authors and do not necessarily represent the official view of the UCLA and CDC/NIOSH in the U.S.

CRediT authorship contribution statement

Yiran Gu: Writing – review & editing, Writing – original draft, Formal analysis, Data curation. **Timothy A. Matthews:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation. **Jian Li:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

We would like to acknowledge and thank the participants in the Midlife in the U.S. (MIDUS) study.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ypmed.2025.108225.

Data availability

Publicly available datasets were analyzed in this study. This data can be found here: https://www.icpsr.umich.edu/web/NACDA/series/203. The statistical SAS syntax supporting the conclusions of this article will be made available by the authors, without undue reservation. Requests to access the statistical SAS syntax should be directed to Dr. Jian Li (jianli2019@ucla.edu).

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