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RESEARCH ARTICLE

Student Debt and Cardiovascular Disease Risk Among U.S. Adults in Early Mid-Life

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Introduction: Student loan debt has become common for young adults in the U.S. and is correlated with poor physical and mental health. It is unclear how the accumulation or repayment of student debt is associated with longer-term cardiovascular risks and chronic inflammation.

Methods: Nationally representative data collected between 1994 and 2018 from >4,000 participants of a U.S. cohort study were analyzed in 2021 to assess the associations among change in student debt between young adulthood and early mid-life, 30-year Framingham cardiovascular disease risk scores, and C-reactive protein levels.

Results: Ordinary least squares regression revealed higher cardiovascular disease and C-reactive protein risks among those in households who became indebted or were consistently in debt between young adulthood and early mid-life than among those in households who were either never in debt or repaid their loans. This pattern persisted after adjustments for degree completion, socioeconomic measures, and other sources of debt.

Conclusions: These findings provide a benchmark for widening health inequalities among a cohort bearing more student debt than any other in U.S. history. As student debt accumulates, within-cohort disparities in cardiovascular disease and related morbidities may undermine the health benefits of postsecondary education.

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INTRODUCTION

Amid rising college costs, declining state and federal support for higher education, and stagnant middle-class wages, student loans have become a prominent form of debt for U.S. households, second only to mortgage debt.[1] The average debtor graduates with >$30,000 in college loans,[2] and this debt has become more difficult for households to repay. Less than half of borrowers in repayment have paid at least $1 toward their principal 5 years into repayment,[3] and default rates for student loans are increasing. It is difficult to discharge this debt through bankruptcy when households are under financial distress, and even borrowers in income-driven repayment plans have difficulty repaying their loans.[4] Although critics argue that student loans remain a sound investment, extant research shows that financial stressors such as debt and economic hardship are negatively associated with biological markers for health.[5–7] No research has examined the link between changes in student debt and biological risks for poor health.

That student loan debt is a source of stress and a mechanism providing access to college presents a puzzle. On one hand, longitudinal findings reveal that higher education—especially a 4-year degree—is associated with lower inflammation and better health.[8–10] Scholars have theorized that postsecondary education protects health because additional years of schooling confer skills, knowledge, and resources. Postsecondary credentials

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also provide access to prestigious, stable, and well-compensated occupations.[10,11]

By contrast, mounting evidence suggests that student debt is a financial stressor that is costly to mental health and well-being. Among young adults, student debt is associated with poorer psychological functioning,[12,13] shorter sleep,[14] and lower life satisfaction.[13] Student debt is also associated with other correlates of cardiovascular disease (CVD), including smoking[15] and hypertension,[16] and could limit the resources available for medical treatment, although evidence is equivocal.[17] Some findings suggest that the association between student debt and poor health is strongest after individuals leave college and enter repayment.[18] There are several limitations to the existing research on this topic. First, although scholars argue that debt repayment stress is a mechanism linking debt and health,[19] most research is cross-sectional and does not assess the health implications of debt repayment and accumulation. Second, research has focused on health behaviors and psychosocial outcomes but has not examined physical health outcomes. Third, most research relies on self-reported measures of both health and debt levels, possibly suffering from shared method bias. It is therefore unclear whether changes in student debt are associated with biological markers for health in panel studies.[20]

Although household debt and specific types of unsecured debt—such as credit card debt—can create financial strain and are associated with poor self-rated[16,21,22] and clinically assessed health,[16] little is known about student debt and cardiovascular health. One possible reason for this omission concerns the relative cardiovascular condition of those with the most student debt. Adults between the ages of 35 and 49 years held a collective $602 million of student debt in Quarter 4 of 2020,[23] and although CVD diagnoses are more common at later ages,[24] the cumulative processes leading to CVD begin earlier in life.[25]

This study contributes to the nascent literature on student debt and health by examining the changes in household student loan debt between young adulthood and early mid-life and 2 related outcomes: 30-year Framingham CVD risk scores and C-reactive protein (CRP) assays tapping inflammation, chronic stress exposure,[26,27] and future disease risk in healthy adults.[28,29] Results of this investigation document how the accumulation and repayment of student debt across the early adult life course are associated with CVD and CRP. Tests for moderation by race and educational attainment are performed because past research suggests that student debt is more burdensome, stressful, and difficult to repay for borrowers of color and college noncompleters.[14,30,31] These associations are analyzed among a cohort in early mid-life, a time when the returns from education have matured, the ritual of student debt repayment is established, and the accumulating consequences of debt-related stress are taking shape.

METHODS

Study Sample

Data came from the National Longitudinal Study of Adolescent to Adult Health (Add Health), a panel study of 20,745 adolescents in Grades 7–12 first interviewed during the 1994−1995 school year.[32] A total of 4 subsequent waves of data were collected from participants after the first wave, including Wave 3 (2001−2002) when respondents were aged 18−26 years (n=15,170) and Wave 5 (2016−2018) when respondents were aged 33−44 years (n=12,300). Wave 5 respondents were invited to in-home medical examinations, with 4,936 respondents consenting to provide biological markers of physiologic health, including blood draws.

Because they are unlikely to have accrued student debt, respondents without a high-school degree/equivalent (n=176) were omitted, as were those pregnant at Wave 5 owing to confounding with inflammation (n=99). Those missing biomarker data (CVD: n=468; CRP: n=359) and, in models assessing inflammation, those with CRP values exceeding 25 mg/L (n=62), which could indicate active proinflammatory infections, were omitted. This yielded samples of 4,193 cases with complete information on CVD risk scores and 4,240 with complete CRP data and no extreme values, with 89% of respondents represented in both subsamples.

Measures

The dependent variables were 30-year Framingham CVD risk scores and CRP assays. CVD risk scores were calculated using the Framingham algorithm[33] drawing on the following variables: sex, age, systolic blood pressure, use of antihypertensive treatments, current cigarette smoking status, diagnosis of diabetes, and BMI. The resulting risk scores measure the likelihood of a cardiovascular outcome over the next 30 years of life, including coronary insufficiency, angina pectoris, claudication and heart failure, ischemic attack, and hard events such as myocardial infarction, stroke, and coronary death.

CRP is a biomarker of chronic or systemic inflammation.[34] Such inflammation is associated with chronic stress exposure[27,35−37] and CVD independently of the Framingham items.[38] The Wave 5 in-home medical examinations utilized dried blood spot collections through capillary finger pricks to obtain specimens for CRP assays,[39] which are provided in mg/L. Both CVD risk scores and CRP assays were log transformed in multivariable models to reduce skewness. In supplementary models, untransformed outcomes were also assessed using generalized linear modeling for gamma-distributed outcomes. These results were statistically similar to those presented in this study.

Household student debt was assessed in the Wave 3 and 5 interviews. In Wave 3, respondents were asked: *Do you (or your husband/wife) have any student loans or other educational loans that have not yet been paid? (yes or no)*. The Wave 5 question asked: *How much do you and others in your household owe altogether for education (including student loans)?* Response options to this item ranged from *1* ($0) to *9* (≥$1,000,000), which was

recoded into a dichotomous measure equal to 0 for those with no student debt and 1 otherwise. Combining the dichotomous Wave 3 and Wave 5 measures yielded a 4-category measure of change in student debt with the following categories: never had student debt (ref), paid-off debt between Waves 3 and 5, took on debt between waves, and consistently in debt. Because research on debt shows that the stress of debt repayment drives the relationship between debt and health,[40,41] the change measure is relied on in the main analyses. Supplementary models estimated the independent association between the levels of Wave 5 student debt and the dependent variables, which produced similar results.

Models are adjusted for respondent, household, and family characteristics measured at Waves 1 and 5. Measures from Wave 1 included Census region (West [ref], Midwest, Northeast, South), highest educational attainment of either residential parent (less than high school [ref], high school or equivalent, 4-year college degree), and parent-reported household income in $1,000s. Measures from Wave 5 included educational attainment (high-school degree or equivalent [ref], some college [no degree], 2-year college degree, 4-year college degree, or graduate/professional degree); race/ethnicity (non-Hispanic White [ref], non-Hispanic Black, Hispanic, Other); sex (male [ref], female); age (standardized); marital status (unmarried [ref], married); number of children in the household (no children [ref], 1 child, ≥2 children); employment status (does not work for pay [ref], works part-time for 10−35 hours/week, works full time ≥35 hours/week); annual household income (<$25,000 [ref], $25,000−$39,999, $40,000−$74,999, $75,000−$99,999, ≥$100,000); mortgage debt (none [ref], household has a mortgage); and other sources of debt, including credit card, medical debt, and legal debt (none [ref], household has other debt). To account for hereditary survival advantages, an indicator of parental survival at the time of the Wave 5 interview (both alive [ref], 1 or both biological parents deceased) was included. Finally, a summative measure of the number of infectious or inflammatory illnesses experienced in the 4 weeks before the Wave 5 interview was included in CRP models.

Statistical Analysis

Missing data were rare—about ≤1% for all variables with 4 exceptions: Wave 3 student debt (11.9%, owing to unit nonresponse at Wave 3), Wave 1 household income (21.7%), Wave 5 household income (6.3%), and parental survivorship (5.5%). Multiple imputations with chained equations were employed to create 40 complete data sets following previous recommendations[42] using Stata's ICE program.[43]

Ordinary least squares regression was used to assess variation in logged CVD risk scores and CRP levels by student debt and covariates. Errors were clustered by Wave 1 school identifiers, and all analyses applied probability weights derived specifically for the subsample completing in-home medical examinations, adjusting for the characteristics of those selected into the subsample. Analyses were performed using Stata, version 16. The study was approved by the Colorado Multiple IRB (COMIRB-16-0361).

RESULTS

Mean values were 0.24 for CVD and 3.32 for CRP (Table 1 provides the differences by student debt). More than one third of respondents (37%) did not report student debt in either wave, whereas 12% paid off their loans, 28% took on student debt, and 24% consistently had debt. The modal educational attainment was a 4-year college degree, followed by some college−no degree, 2-year college degree, graduate/professional degree, and high school/equivalent.

Table 2 reports the ordinary least squares regression results of logged CVD risk scores and CRP levels. Results from the first model, adjusted for all covariates, revealed that respondents who consistently had debt (b=0.06, p=0.035) or took on debt (b=0.08, p=0.01) had higher CVD risk scores than those never in debt. In addition, respondents who paid-off debt had significantly lower CVD risk scores than those never in debt (b= −0.07, p=0.015). Changing the reference group (ref=repaid debt) revealed that those who took on new debt (b=0.15, p<0.001) or were consistently in debt (b=0.13, p<0.001) had higher CVD risks than those who paid off their loans. Results from the second model showed that those consistently in debt had higher CRP levels than those who never had such debt (b=0.21, p=0.004) or repaid it (b=0.32, p<0.001). Those taking on debt similarly showed higher CRP levels than those who repaid their loans (b=0.21, p=0.014).

Figure 1 illustrates these results as marginal mean predictions of CVD risk scores and CRP levels in their natural metric. The estimates indicated clinically significant CRP values (i.e., >3.0) for those who took on new debt ($\hat{y}$=3.3) or were consistently in debt ($\hat{y}$=3.69) between young adulthood and early mid-life (net of all covariates in Table 1), estimates that exceed their counterparts who never had debt ($\hat{y}$=3.0) or paid it off ($\hat{y}$=2.68) Figure 1. also confirms the higher cardiovascular risks for those in debt on reaching early mid-life than for those without debt.

Omission of community features could bias these associations. Supplemental models adjusted for urban−rural codes, tract-level household income and college completion, Cost of Living Index, and socioeconomic mobility of youth at the tract level. The results (available on request) were substantively and statistically similar to those presented in this study. In addition, improvements on the approximation of hereditary survival advantages through parental survivorship were attempted by adding polygenic indices of myocardial infarction among non-Hispanic White respondents (i.e., those for whom polygenic indices are well validated) to the model for CVD. Details on genetic data in Add Health have been published elsewhere.[44] Following standard practice, the top 10 principal components of the variance−covariance matrix of the genetic data were controlled.[45] Results were consistent with the main findings (Appendix Table 1, available online).

Table 1. Sample Description by Student Debt Status

Variables	Never in debt	Paid-off debt	Took on debt	Consistently in debt
Framingham 30-year CVD risk score	0.24	0.21	0.25	0.24
CRP (mg/L)	3.07	2.56	3.37	3.37
Educational attainment				
High school/equivalent (ref)	0.28	0.04	0.10	0.01
Some college	0.28	0.24	0.34	0.15
2-year college degree	0.16	0.16	0.20	0.15
4-year college degree	0.20	0.40	0.22	0.39
Graduate or professional degree	0.08	0.17	0.14	0.31
Female	0.47	0.49	0.50	0.52
Age	37.18	37.63	37.15	37.53
Race/ethnicity				
Non-Hispanic White (ref)	0.75	0.78	0.65	0.64
Non-Hispanic Black	0.09	0.07	0.22	0.23
Hispanic	0.13	0.09	0.10	0.09
Other race/ethnicity	0.03	0.06	0.02	0.04
Married	0.59	0.68	0.58	0.62
Count of children in the household				
None (ref)	0.36	0.34	0.35	0.34
1	0.16	0.12	0.20	0.23
≥2	0.48	0.54	0.45	0.43
Employment status				
Not working for pay (ref)	0.19	0.15	0.19	0.12
Part-time (10–35 hours/week)	0.12	0.07	0.11	0.09
Full time (≥35 hours/week)	0.69	0.78	0.71	0.78
Household income, $				
<25,000 (ref)	0.15	0.04	0.14	0.08
25,000–39,999	0.10	0.07	0.12	0.09
40,000–74,999	0.29	0.26	0.28	0.27
75,000–99,999	0.17	0.16	0.16	0.16
≥100,000	0.28	0.47	0.30	0.39
Household has mortgage debt	0.68	0.78	0.68	0.69
Household has other sources of debt	0.81	0.78	0.94	0.93
Parental education, Wave 1				
Less than high school (ref)	0.11	0.03	0.08	0.05
High school/equivalent	0.56	0.54	0.59	0.50
4-year college degree	0.34	0.43	0.34	0.45
Household income in thousands, Wave 1	53.21	51.57	46.57	45.36
Survivorship of biological parents				
Neither deceased (ref)	0.69	0.77	0.70	0.71
One or both biological parents deceased	0.31	0.23	0.30	0.29
Region, wave 1				
West (ref)	0.19	0.15	0.15	0.11
Midwest	0.32	0.36	0.34	0.41
South	0.40	0.35	0.41	0.36
Northeast	0.10	0.15	0.10	0.11
Count of recent inflammatory conditions	0.36	0.33	0.40	0.40

Estimates on debt status are shown as proportions or arithmetic means.
CRP, C-reactive protein; CVD, cardiovascular disease.

Finally, supplemental analyses included interaction terms to assess effect moderation by race/ethnicity and educational attainment. Results revealed no evidence of moderation by race/ethnicity for CVD or CRP, whereas the interaction between a simplified dichotomous measure of 4-year degree completion suggested that the

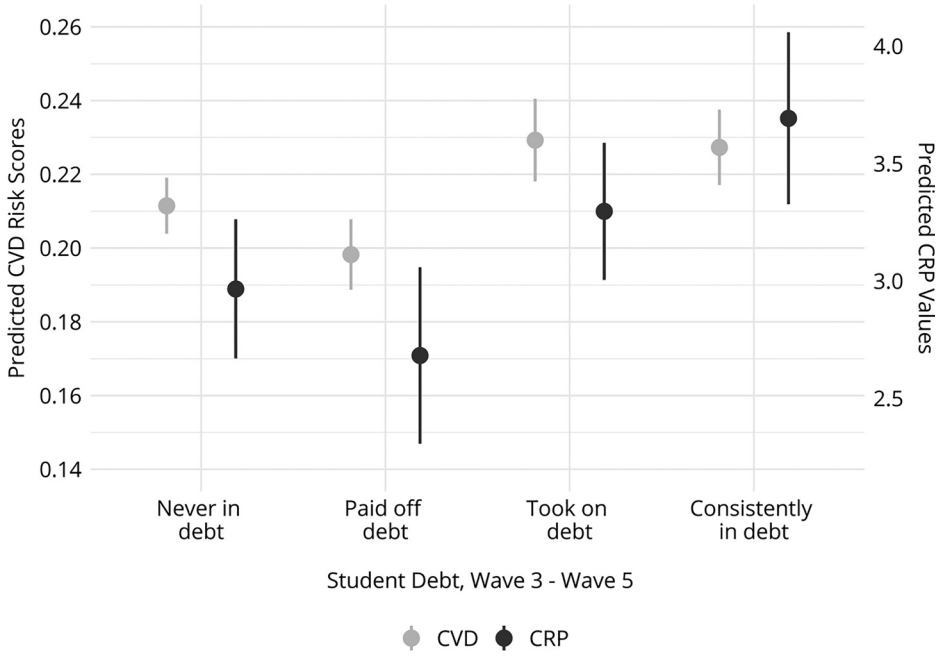

Figure 1. Marginal mean predicted CVD risk scores and CRP levels.
Notes: Estimates are in their natural metric and based on multiply-imputed data, corrected for survey design and adjusted for all variables shown in Table 1. Error bars represent 95% CIs.
CVD, cardiovascular disease; CRP, C-reactive protein.

college premium for cardiovascular health (but not CRP) was diminished for those with student debt Figure 2. summarizes these results in the form of marginal mean predicted CVD risk scores.

DISCUSSION

Student loan debt is common, with most college-going students taking on such debt.[2] Although having a college degree is associated with better health,[8,9] previous research shows that other forms of debt (e.g., credit card) are financial stressors associated with poorer health.[46] This study investigates the link between changes in student debt across early adulthood and 30-year Framingham CVD risk scores and CRP. Results show that respondents in households that were consistently in debt or took on debt across early adulthood had higher CVD risk and inflammation than their counterparts without such debt by early mid-life. In addition, there were possible cardiovascular advantages among those who repaid their loans compared with that among those who never had student debt. Thus, the risks and returns of student loan debt are a double-edged sword[47]: as a resource for access to college, student loans may be helpful—at least for those who can repay them. Indeed, this study shows that the magnitude of the protective benefits of degree completion and higher income outweigh the risks of student loan debt. Even so, for borrowers who struggle to repay student debt, the health benefits of a college degree could be attenuated.

Similar to other recent work showing higher levels of inflammation at younger ages than previously realized,[9] these findings suggest that the later-life origins of CVD and related inflammation are observable in the transition from young adulthood to early mid-life and exacerbated by student debt as well as low education.[9] Previous research shows that student debt is a financial stressor that undermines self-reported mental and psychosocial health in cross-sectional data,[12,18] and this study shows that student debt is also associated with biological risk indicators. This has 2 implications. First, findings from previous research are not likely driven by shared methods bias, resulting from the self-reporting of both student debt and health. Second, these results provide a window into the potential long-term consequences of student debt for health. To the extent that elevated CVD risk and inflammation in early mid-life are predictive of later-life chronic disease,[25,48] student debt may increase the risks for CVD-related morbidity and mortality as this cohort ages. Supplemental analyses suggest that on balance, degree completion provides health benefits even to those with student debt, although these benefits are attenuated relative to that of nondebtors. This suggests that the stress and financial austerity linked to student

Table 2. Regression Models of CVD Risk and CRP Levels

Variables	CVD (*n*=4,193)			CRP (*n*=4,240)		
	b	SE	*p*-value	b	SE	*p*-value
Student loan debt (ref = never in debt)						
Paid-off debt	−0.07	0.03	**0.019**	−0.11	0.08	0.159
Took on debt	0.08**	0.03	**0.009**	0.10*	0.06	0.114
Consistently in debt	0.06**	0.03	**0.036**	0.21**	0.07	**0.004**
Educational attainment (ref = high school/equivalent)						
Some college	−0.11	0.04	**0.002**	−0.07	0.08	0.389
2-year college degree	−0.13	0.04	**0.005**	−0.18	0.10	0.072
4-year college degree	−0.23	0.04	**<0.001**	−0.24	0.09	**0.012**
Graduate or professional degree	−0.26	0.05	**<0.001**	−0.24	0.10	**0.022**
Race/ethnicity (ref = non-Hispanic White)						
Non-Hispanic Black	0.06	0.03	0.053	−0.01	0.07	0.987
Hispanic	−0.06	0.04	0.122	0.04	0.08	0.672
Other race/ethnicity	−0.07	0.06	0.236	−0.18	0.17	0.292
Employment status (ref = not working for pay)						
Part-time (10–35 hours/week)	−0.09	0.04	**0.014**	−0.22	0.09	**0.020**
Full time (≥35 hours/week)	−0.04	0.03	0.740	−0.01	0.08	0.945
Household income (ref ≤$25,000)						
$25,000–$39,999	−0.12	0.05	**0.011**	−0.22	0.11	0.057
$40,000–$74,999	−0.10	0.04	**0.024**	−0.18	0.10	0.064
$75,000–$99,999	−0.16	0.05	**0.002**	−0.21	0.10	**0.048**
≥$100,000	−0.20	0.04	**<0.001**	−0.43	0.11	**<0.001**
Household has mortgage debt	−0.07	0.02	**0.002**	−0.05	0.06	0.365
Household has other sources of debt	0.15	0.02	**<0.001**	0.19	0.07	**0.010**
Count of recent inflammatory conditions	–			0.20	0.04	**<0.001**

Note: Boldface indicates statistical significance ($p<0.05$).
Estimates are adjusted for all variables shown in Table 1 and for design effects of the Add Health study. Significant differences relative to the paid-off debt category are denoted with
*$p<0.05$.
**$p<0.001$.
Add Health, National Longitudinal Study of Adolescent to Adult Health; CRP, C-reactive protein; CVD, cardiovascular disease.

loan debt could lead to growing disparities in CVD risk among the college educated as this cohort ages.

The findings also contribute to the burgeoning literature on financial strain, economic hardship, and health.[5–7] Although this research tends to focus on socially and economically disadvantaged populations, this study shows that student debt may create financial strain among otherwise advantaged populations. Taken together, these findings underscore the potential population health implications of transitioning to debt-financed education in the U.S. Although the empirical evidence is clear on the economic and health returns from a college degree,[49] these advantages come at a cost for borrowers.

Limitations

The study is not without limitations. First, student debt is measured at the household level, potentially conflating a respondent's debt with that of family members, including grown coresidential children. To examine this, models were replicated with the subset of respondents without children aged >17 years, yielding results that were similar to those shown in this study. Second, CRP and CVD are measured only at a single point in time, which cannot identify the factors associated with changing cardiovascular health. Future research should leverage Add Health data once they become available to further examine how student debt (and changes therein) is associated with trajectories of cardiovascular health. Third, participants consenting to the in-home medical examination and blood draws used to derive cardiovascular measures, and CRP assays were not chosen at random, and selection bias could be of concern, although the weights provided by Add Health—the weights used in this study—are designed to adjust for selection. Relatedly, selection into and out of indebtedness likely varies by factors not included in this analysis, such as duration

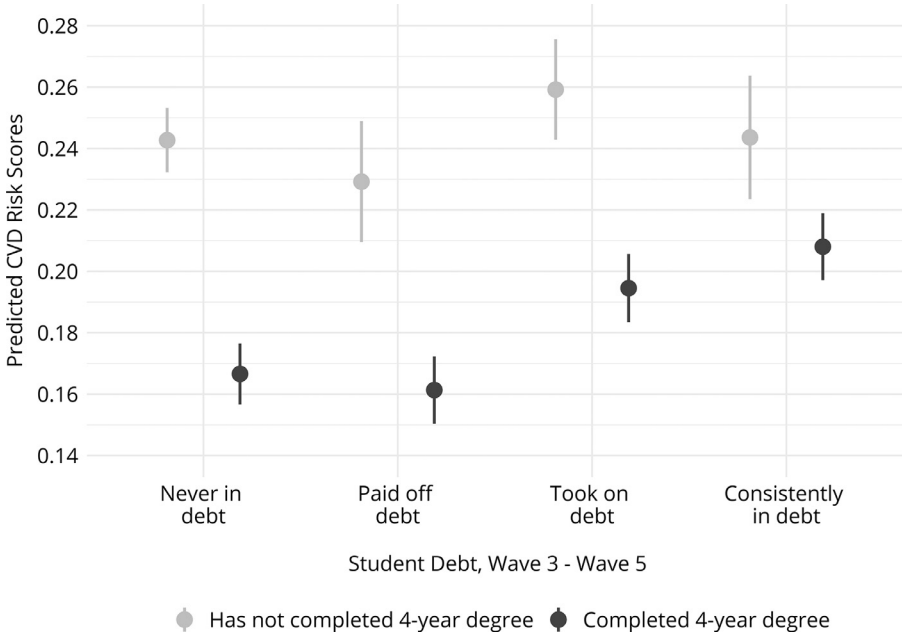

Figure 2. Marginal mean predicted CVD risk scores by degree completion and student debt.
Notes: Estimates are in their natural metric and based on multiply-imputed data, corrected for survey design and adjusted for all variables shown in Table 1. Error bars represent 95% CIs.
CVD, cardiovascular disease.

of indebtedness. Thus, omitted variables and the use of imperfect measures of SES and wealth in childhood and adulthood may bias the results.

CONCLUSIONS

Notwithstanding its limitations, this study suggests that student debt attenuates the health benefits of college completion and the socioeconomic advantages of a 4-year credential. This study joins a growing body of research showing that student debt is a financial stressor that undermines population health. For cohorts who came of age and attended college in an era of debt-financed higher education, student debt may have long-term health consequences and accelerate physiologic weathering. Although the study design cannot offer conclusions regarding causality, the results suggest that policies that facilitate reinvestment in public higher education, authorize loan forgiveness, or eliminate interest on student loans to accelerate repayment may improve the health of college-going populations. Future research should explore the extent to which rising debt is associated with declining levels of and disparities in population health.

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CREDIT AUTHOR STATEMENT

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SUPPLEMENTAL MATERIAL

Supplemental materials associated with this article can be found in the online version at https://doi.org/10.1016/j.amepre.2022.02.002.

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