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Financial strain is associated with poorer cardiovascular health: The multi-ethnic study of atherosclerosis

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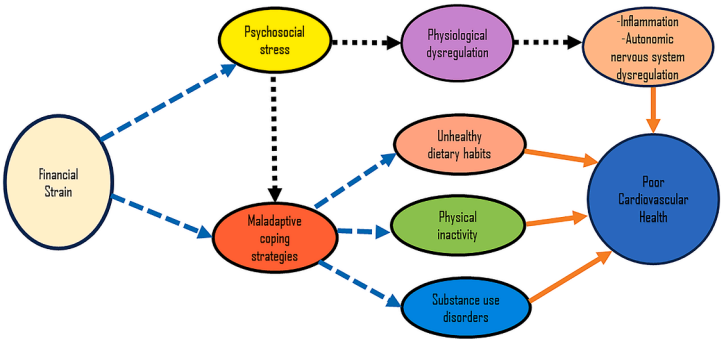
GRAPHICAL ABSTRACT

Central Illustration. Potential mechanisms linking financial strain to poor cardiovascular health.



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ABSTRACT

Objective: Psychosocial stress is associated with increased cardiovascular disease (CVD) risk. The relationship between financial strain, a toxic form of psychosocial stress, and ideal cardiovascular health (CVH) is not well established. We examined whether financial strain was associated with poorer CVH in a multi-ethnic cohort free of CVD at baseline.

Methods: This was a cross-sectional analysis of 6,453 adults aged 45–84 years from the Multi-Ethnic Study of Atherosclerosis. Financial strain was assessed by questionnaire and responses were categorized as yes or no. CVH was measured from 7 metrics (smoking, body mass index, physical activity, diet, total cholesterol, blood glucose and blood pressure). A CVH score of 14 was calculated by assigning points to the categories of each metric (poor = 0 points, intermediate = 1 point, ideal = 2 points). Multinomial logistic regression was used to examine the association of financial strain with the CVH score (inadequate 0–8, average 9–10, and optimal 11–14 points) adjusting for sociodemographic factors, depression and anxiety.

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Results: The mean age (SD) was 62 (10) and 53 % were women. Financial strain was reported by 25 % of participants. Participants who reported financial strain had lower odds of average (OR, 0.82 [95 % CI, 0.71, 0.94]) and optimal (0.73 [0.62, 0.87]) CVH scores. However, in the fully adjusted model, the association was only significant for optimal CVH scores (0.81, [0.68, 0.97]).
Conclusion: Financial strain was associated with poorer CVH. More research is needed to understand this relationship so the burden of CVD can be decreased, particularly among people experiencing financial hardship.

1. Introduction

Cardiovascular disease (CVD) is still the leading cause of morbidity and mortality in the United States and globally, disproportionately affecting people of lower socioeconomic status [1,2]. Psychosocial stress is associated with an increased risk of CVD, such as acute myocardial infarction [3,4]. Financial strain is a toxic form of psychosocial stress that has been linked to poorer quality of life, poorer health outcomes and increased healthcare utilization [5].

As part of a strategy to prevent and reduce CVD morbidity and mortality, the American Heart Association (AHA) developed the construct of cardiovascular health (CVH) to promote the attainment of ideal CVH, a shift in focus from disease prevention to the promotion of wellness [6–8]. A person achieves ideal CVH by meeting specific criteria for seven CVH metrics (**Table S1**) [6]. More recently the AHA updated the CVH score to include sleep, now known as the "Life's Essential 8″ metrics [9]. Prior studies show that ideal CVH is associated with a decrease in CVD incidence, as well as non-CVD and all-cause mortality [10–17].

Although the literature on the impact of financial strain on ideal CVH is sparse, a recent study conducted among middle-aged to older women from the Women's Health Study showed that financial strain was associated with poorer CVH [18]. Other studies that examined the association between socioeconomic status and ideal CVH found that higher individual, family or neighborhood income was associated with better CVH [19–21]. The aim of our study is to examine the relationship between financial strain and ideal CVH in a multi-ethnic cohort of men and women free of CVD at baseline. Understanding this relationship may provide opportunities for targeted intervention and prevention strategies in efforts to further decrease CVD morbidity and mortality, particularly among people experiencing financial hardships. We hypothesize that participants from the Multi-Ethnic Study of Atherosclerosis (MESA) with financial strain will have poorer CVH, measured by the composite CVH score, number of ideal metrics and individual CVH metrics.

2. Methods

2.1. Study population

The Multi-Ethnic Study of Atherosclerosis is a cohort study conducted to explore the characteristics of subclinical CVD and risk factors that may predict the progression to clinical CVD. Baseline data collection occurred between July 2000 and August 2002 from 6814 men and women aged 45 to 84 years with no history of clinical CVD at baseline. Participants were recruited from six US centers (Baltimore, MD; Chicago, IL; Los Angeles, CA; Forsyth County, NC; New York, NY; St. Paul, MN). Thirty-eight percent of participants were White Americans, 12 % Chinese Americans, 28 % Black Americans and 22 % Hispanic Americans. Standardized questionnaires, fasting laboratory blood tests and physical examinations were used to obtain baseline data from participants. The institutional review boards at each recruitment center approved the MESA study protocol and all participants provided written informed consent. The detailed methodology and procedures of the MESA study have been previously reported [22].

2.2. Financial strain

Financial strain was assessed at baseline among study participants of the MESA cohort from the following questions: 1. "Are you experiencing ongoing financial strain?"; 2. "Has this been a problem for 6 months or more?" For the main analysis, financial strain was categorized as "Yes" or "No" from the self-reported responses provided to the first question. In the supplemental analysis, financial strain of 6 months or more, was categorized as "Yes" or "No" from the responses provided to the second question.

2.3. Cardiovascular health

According to prior literature, [6]. CVH is defined using the ideal levels for seven modifiable health behaviors and factors. These include: (i). non-smoking; (ii). body mass index (BMI) <25 kg/m^2; (iii). weekly physical activity of 75 min of vigorous exercise or 150 min of moderate exercise; (iv). a healthy diet consistent with recommended guidelines; (v). untreated total cholesterol <200 mg/dL; (vi). untreated blood pressure <120/<80 mmHg and (vii). untreated fasting blood glucose <100 mg/dL. We did not include sleep in the CVH score because sleep was not assessed at the MESA baseline.

Using a self-report questionnaire, information on the smoking status of the study participants was obtained and defined as non-smokers (not smoking or quit smoking >12 months), former smokers (quit smoking within the previous 12 months), and current smokers. The measured weights and heights of the study participants were used to calculate BMI and was reported in kg/m^2. Physical activity was assessed from an adapted self-report survey from the Cross-Cultural Activity Participation Study [23]. The survey contained 28 questions on the time and frequency of activities in a week in the past month. Physical activity was defined as the total number of minutes for moderate and vigorous exercise which was calculated in metabolic equivalent of task (MET/min) [24]. A validated food frequency questionnaire with 120 items adapted from the Insulin Resistance Atherosclerosis Study was used to collect information on the dietary habits of the participants during the previous year [25,26]. Based on recommended dietary guidelines, a healthy diet score includes multiple components - fruits and vegetables, fish, whole grains, sodium intake <1500 mg per day and sugar-sweetened beverages ≤450 kcal (36 oz.) per week [6]. For assessing total cholesterol (mg/dL), blood was drawn after a 12-hr fast. The cholesterol oxidase method was used to measure total cholesterol in ethylenediaminetetraacetic (EDTA) plasma using a centrifugal analyzer (Roche Diagnostic). Blood glucose was measured by the glucose oxidase method on a Vitros analyzer (Johnson & Johnson). Three separate blood pressure readings were taken from participants after 5 min of rest in a seated position using an automated oscillometric sphygmomanometer (Dinamap model Pro 100; Critikon) and the final blood pressure measurement was calculated using the mean of the last two blood pressure readings.

2.4. Covariates

The baseline covariates included in this study were sociodemographic factors, including age, sex, race/ethnicity, education, income, health insurance status and study site. We assessed age as a continuous variable, while sex was grouped into male and female. Study

participants self-identified as White, Chinese, Black, or Hispanic American. Education and income were dichotomized as ≥ Bachelor's degree vs. < Bachelor's degree and ≥$40,000 vs. <$40,000 per annum, respectively. Participants responded "Yes" or "No" to having health insurance. Additional covariates included depression and anxiety assessed as continuous variables using the Center for Epidemiologic Studies – Depression (CESD) Scale and Spielberger Trait Anxiety Scale, respectively.

2.5. Statistical analysis

The baseline characteristics for the overall study population and by the CVH score were presented as means with standard deviation (SD) (continuous variables) or frequencies with percentages (categorical variables). The ANOVA and Chi-square tests were used to examine the differences in the prevalence of participants' characteristics stratified by the presence or absence of financial strain. Each CVH metric was categorized into poor, intermediate, and ideal as presented in **Table S1**. Points were assigned to the categories of the CVH metrics (0 for poor, 1 for intermediate, and 2 for ideal), giving a total CVH score ranging from 0 to 14. Based on previous studies, the CVH score was categorized as inadequate (0–8), average (9–10) and optimal (11–14). The number of ideal metrics was obtained by counting the number of metrics in the ideal category for each CVH metric and this was categorized into 0–1, 2–3, 4–5 and 6–7 ideal metrics.

We estimated the associations of financial strain with the CVH score and the number of ideal metrics using multinomial logistic regression. We fitted 2 separate models. In model 1 we adjusted for sociodemographic factors including age, sex, race/ethnicity, education, income, health insurance status and MESA study site. Model 2 was additionally adjusted for depression and anxiety. Odds ratios (ORs) and the corresponding 95 % CIs were estimated for the average and optimal CVH scores. The reference group was the "inadequate score" for the CVH score, while the reference group for the number of ideal metrics was "0–1″. We tested for statistical interaction by age (<65 versus ≥65 years), sex and race/ethnicity by inserting interaction terms in model 2. In addition, we estimated the associations between financial strain and each of the individual CVH metrics using multinomial logistic regression adjusted for the previously described model 1 and model 2 covariates. The reference group was the "poor" category for the CVH metrics. Furthermore, we examined the associations of financial strain of 6 months or more with the CVH score and number of ideal metrics in a supplemental analysis. We presented the graphical representations of the proportion of study participants with or without financial strain by CVH score. All analyses were performed using STATA version 15.0 (StataCorp LP, College Station, TX) and the statistical significance level was set at α=0.05 for 2-sided tests.

3. Results

The study sample comprised 6453 participants with a mean age (SD) of 62 (10) years and 53 % women. The study sample's characteristics varied by the presence or absence of financial strain. Among participants with financial strain, 68 % had <bachelor's degree and 62 % had an income <$40,000 per annum (Table 1). Detailed demographic characteristics of the study sample by the presence or absence of financial strain are described in Table 1 and by CVH scores in **Table S2**. As illustrated in Fig. 1, participants with financial strain had a higher proportion of inadequate CVH scores than those without financial strain ($p < 0.0001$).

Compared to participants without financial strain, those with financial strain had lower odds of having average and optimal CVH scores (OR, 0.82 [95 % CI, 0.71, 0.94] and 0.73 [0.62, 0.87], respectively) (Table 2). However, the association was slightly attenuated in the second model with depression and anxiety and only remained statistically significant for optimal CVH scores (0.81, [0.68, 0.97]). In addition, the presence of financial strain was associated with lower odds of having 4–5 and 6–7 ideal metrics (0.70, [0.55, 0.88] and 0.66, [0.46, 0.95], respectively). In model 2, the association was attenuated and only statistically significant for 4–5 ideal metrics (0.78, [0.61, 0.99]) (Table 2).

Table 1
Characteristics of study participants at the MESA baseline exam by financial strain, $N = 6453$.

	Total	FS absent	FS present	P-value
CVH score				<0.001
Inadequate	3053 (47 %)	2185 (45 %)	868 (54 %)	
Average	2101 (33 %)	1621 (34 %)	480 (30 %)	
Optimal	1299 (20 %)	1027 (21 %)	272 (17 %)	
Age, years				
Mean (SD)	62 (10)	63 (10)	58 (10)	
<65	3687 (57 %)	2519 (52 %)	1168 (72 %)	<0.001
≥65	2766 (43 %)	2314 (48 %)	452 (28 %)	
Sex				<0.001
Men	3049 (47 %)	2390 (49 %)	659 (41 %)	
Women	3404 (53 %)	2443 (51 %)	961 (59 %)	
Race/ethnicity				<0.001
White	2518 (39 %)	1973 (41 %)	545 (34 %)	
Chinese-American	794 (12 %)	669 (14 %)	125 (8 %)	
Black	1693 (26 %)	1164 (24 %)	529 (33 %)	
Hispanic	1448 (22 %)	1027 (21 %)	421 (26 %)	
Education				<0.001
≥Bachelor's degree	2316 (36 %)	1802 (37 %)	514 (32 %)	
<Bachelor's degree	4137 (64 %)	3031 (63 %)	1106 (68 %)	
Income				<0.001
≥$40,000	3194 (50 %)	2578 (53 %)	616 (38 %)	
<$40,000	3259 (51 %)	2255 (47 %)	1004 (62 %)	
Health insurance				<0.001
Yes	5876 (91 %)	4505 (93 %)	1371 (85 %)	
No	577 (9 %)	328 (7 %)	249 (15 %)	

Abbreviations: CVH, Cardiovascular health; FS, Financial strain; MESA, Multi-Ethnic Study of Atherosclerosis. Data were presented as frequency (percent) and mean (SD). Decimals were rounded up to whole numbers.

The multivariable-adjusted associations between financial strain and the individual CVH metrics are reported in Table 3. Participants with financial strain had 21 % lower odds of having the ideal smoking metric, but this association was no longer statistically significant in model 2. Participants with financial strain had 17 % and 23 % lower odds of having intermediate and ideal BMI, respectively. Participants with financial strain had 18 % lower odds of having ideal physical activity, but the association was no longer statistically significant in the fully adjusted model. For the dietary metric, the presence of financial strain was associated with 16 % and 59 % lower odds of having an intermediate and ideal diet, but the associations were not statistically significant in model 2. Financial strain was associated with 27 % lower odds of having ideal glucose levels with a slightly attenuated magnitude of 24 % in the fully adjusted model. There was no evidence of statistically significant associations of financial strain with total cholesterol and blood pressure. We did not find any evidence of statistical interaction by age, sex or race/ethnicity ($p > 0.05$). In supplemental analysis, we found a similar association between the presence of financial strain for 6 months or more and the CVH score as well as the number of ideal metrics and the individual CVH metrics (**Tables S3 & S4**).

4. Discussion

In this cross-sectional analysis of 6453 adults free of clinical CVD at baseline, participants experiencing financial strain had lower odds of having average and optimal CVH scores. Similarly, we found that the presence of financial strain was associated with lower odds of having 4–5 and 6–7 ideal metrics. Furthermore, participants with financial strain had lower odds of having ideal BMI and glucose. We did not find statistically significant associations with the other CVH metrics.

The findings of our study are supported by the results of a prior cross-sectional study that examined the association between financial strain

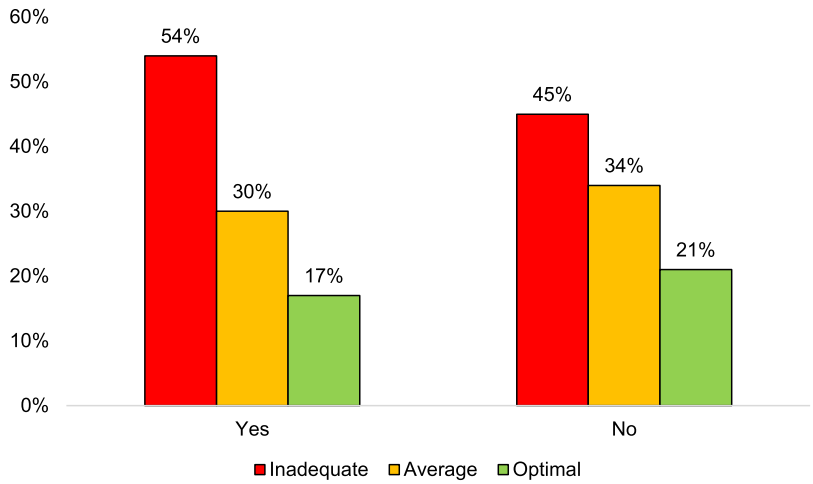

Fig. 1. Financial strain by cardiovascular health score. Yes: Presence of financial strain; No: Absence of financial strain. Red: inadequate (0–8 points); Orange: average (9–10 points); and Green: optimal (11–14 points).

Table 2
Association between financial strain and CVH, $N = 6453$.

	Cardiovascular health score					
	Average		Optimal	Average		Optimal
Financial strain	Model 1			Model 2		
No	Reference		Reference	Reference		Reference
Yes	**0.82 (0.71, 0.94)**		**0.73 (0.62, 0.87)**	0.88 (0.76, 1.01)		**0.81 (0.68, 0.97)**
	Number of ideal metrics					
	2–3	4–5	6–7	2–3	4–5	6–7
Financial strain	Model 1			Model 2		
No	Reference	Reference	Reference	Reference	Reference	Reference
Yes	0.80 (0.64, 1.00)	**0.70 (0.55, 0.88)**	**0.66 (0.46, 0.95)**	0.87 (0.69, 1.10)	**0.78 (0.61, 0.99)**	0.76 (0.52, 1.12)

Abbreviations: CVH, Cardiovascular health.
Odds ratios were derived from multinomial logistic regression models.
The results in bold font are statistically significant at $p < 0.05$.
Model 1 was adjusted for age, sex, race/ethnicity, education, income, health insurance and study site.
Model 2 was adjusted for Model 1 covariates, depression and anxiety.
The reference group of the cardiovascular health score is the inadequate category.
The reference group of the number of ideal metrics is 0–1 ideal metrics.

and CVH in middle-aged and older women using data from the Women's Health Study [18]. In the multinomial regression analysis adjusting for age, race/ethnicity, education and income, an increasing number of financial stressors was associated with a decreased likelihood of having ideal CVH. For example, one, two and three or more financial stressors were associated with 32 %, 50 %, and 77 % lower odds of having ideal CVH scores. Similarly, one, two and three or more financial stressors were associated with 23 %, 38 %, and 59 % lower odds of having intermediate CVH scores [18].

There are several potential mechanisms by which financial strain may worsen cardiovascular health (Central Illustration). For example, financial strain is associated with psychosocial stress, which may lead to physiological dysregulation of the stress response systems [27–30]. This dysregulation has been linked to elevated levels of serum inflammatory biomarkers such as interleukin-6, interleukin-1β, and C-reactive protein [31–34]. Furthermore, maladaptive coping strategies may mediate the association between financial strain and poor cardiovascular health through unhealthy dietary habits, lack of physical activity, and substance use disorders in addition to poor management of stress, anxiety and depression [5,30].

One in three US adults experiences financial strain, [35] which is more commonly associated with low socioeconomic status. Moreover, low socioeconomic status is a known risk factor for poorer health outcomes, which is partly due to unhealthy lifestyles [36–38] but also associated with reduced access to healthcare and preventive services [39]. In the INTERHEART study, individuals with severe financial strain had a higher odds (1.33 [1.19–1.48]) of acute myocardial infarction compared to those with little or no financial strain with a population attributable risk of 11 % (7 %−14 %) [3]. Therefore, economic strategies that reduce financial strain in the general population may likely improve CVH and may decrease the overall burden of CVD. For example, a financial assistance program provided by Kaiser Permanente led to a considerable increase in healthcare utilization and detection of medical conditions although the impact was for a short duration of time [40]. In addition, financial strain may serve as a useful screening tool for poor CVH, which can be followed by implementing targeted interventions at the individual and population levels.

This study has some limitations. First, this is a cross-sectional study, therefore, we cannot determine temporality or make causal inferences about the association between financial strain and CVH. In addition, there is a possibility for reverse causality. Second, the use of self-report questionnaires to obtain information for financial strain and some of the

Table 3
Association between financial strain and the CVH metrics, $N = 6453$.

	Model 1	Model 2
Smoking		
Poor	Reference	Reference
Intermediate	0.57 (0.32, 1.00)	0.57 (0.31, 1.02)
Ideal	**0.79 (0.67, 0.93)**	0.85 (0.72, 1.02)
Body mass index		
Poor	Reference	Reference
Intermediate	**0.82 (0.72, 0.95)**	**0.83 (0.72, 0.96)**
Ideal	**0.76 (0.65, 0.90)**	**0.77 (0.65, 0.91)**
Physical activity		
Poor	Reference	Reference
Intermediate	1.10 (0.92, 1.32)	1,15 (0.95, 1.39)
Ideal	**0.82 (0.71, 0.95)**	0.90 (0.77, 1.04)
Diet		
Poor	Reference	Reference
Intermediate	**0.84 (0.74, 0.95)**	0.89 (0.78, 1.01)
Ideal	**0.41 (0.20, 0.85)**	0.49 (0.23, 1.04)
Total cholesterol		
Poor	Reference	Reference
Intermediate	0.93 (0.77, 1.12)	0.90 (0.74, 1.09)
Ideal	1.06 (0.88, 1.27)	1.04 (0.86, 1.25)
Blood pressure		
Poor	Reference	Reference
Intermediate	1.01 (0.87, 1.18)	1.02 (0.87, 1.20)
Ideal	1.02 (0.88, 1.19)	1.07 (0.91, 1.25)
Blood glucose		
Poor	Reference	Reference
Intermediate	**0.78 (0.62, 0.99)**	0.81 (0.64, 1.04)
Ideal	**0.73 (0.60, 0.88)**	**0.76 (0.62, 0.92)**

Abbreviations: CVH, Cardiovascular health.
Independent variable is financial strain; dependent variables are the CVH metrics.
Odds ratios were derived from multinomial logistic regression models.
The results in bold font are statistically significant at $p < 0.05$.
Model 1 was adjusted for age, sex, race/ethnicity, education, income, health insurance and study site.
Model 2 was adjusted for Model 1 covariates, depression and anxiety.

individual CVH metrics, i.e., smoking, diet, and physical activity, may be subject to recall bias. Third, this sample was predominantly adults of middle to older ages, so the findings might not be generalizable to younger or elderly people. Fourth, the nuances of financial strain of the participants in this study may not have been properly captured because the response to the question of ongoing financial strain was dichotomized as "Yes" or "No". Finally, financial strain and CVH were measured only at baseline and may not reflect the future financial and CVH status of study participants. The strengths of this study include the racially/ethnically diverse population, and the rigorous and standardized methods for data collection.

5. Conclusions

In conclusion, in this multi-ethnic cohort of adults free of CVD at baseline, participants experiencing financial strain were less likely to have favorable CVH. This finding underscores the importance of promoting and preserving favorable CVH among people experiencing financial hardship. There is need for future longitudinal studies to examine the causal pathways between financial strain and unfavorable CVH so that effective policies and public health interventions that promote favorable CVH can be implemented. Additional studies could also examine how financial strain affects the updated construct of CVH that includes sleep health [9].

Conflicts of interest

Unrelated to this work, Dr. Michos has served as a consultant for Amgen, Amarin, AstraZeneca, Bayer, Boehringer Ingelheim, Edwards Life Science, Esperion, Medtronic, Merck, New Amsterdam, Novartis, Novo Nordisk, and Pfizer. The authors have no conflicts of interest.

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CRediT authorship contribution statement

Olatokunbo Osibogun: Conceptualization, Formal analysis, Methodology, Visualization, Writing – original draft, Writing – review & editing. **Oluseye Ogunmoroti:** Conceptualization, Formal analysis, Methodology, Software, Visualization, Writing – original draft, Writing – review & editing. **Ruth-Alma Turkson-Ocran:** Methodology, Visualization, Writing – review & editing. **Victor Okunrintemi:** Methodology, Visualization, Writing – review & editing. **Kiarri N. Kershaw:** Methodology, Visualization, Writing – review & editing. **Norrina B. Allen:** Methodology, Visualization, Writing – review & editing. **Erin D. Michos:** Methodology, Visualization, Supervision, Writing – review & editing.

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.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ajpc.2024.100640.

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