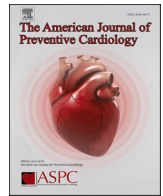


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Original Research

Psychological and socio-economic correlates of cardiovascular health among young adults in Puerto Rico

Milagros C. Rosal^{a,1,*}, Israel Almodóvar-Rivera^b, Sharina D. Person^a, Andrea López-Cepero^c,
Catarina I. Kiefe^a, Katherine L. Tucker^d, Maria Uribe-Jerez^a, José Rodríguez-Orengo^{e,f},
Cynthia M. Pérez^{g,1}

^a Department of Population and Quantitative Health Sciences, University of Massachusetts Chan Medical School, Office of Health Equity, 55 Lake Avenue N, S2-106, Worcester, MA, USA

^b Department of Mathematical Sciences, College of Arts and Sciences, Mayaguez Campus, University of Puerto Rico, Mayaguez, PR, USA

^c Department of Epidemiology, Emory University, Atlanta, GA, USA

^d Department of Biomedical and Nutritional Sciences, Zucker College of Health Sciences, University of Massachusetts Lowell, Lowell, MA, USA

^e Fundación de Investigación (FDI) Clinical Research, San Juan, PR, USA

^f Department of Biochemistry, School of Medicine, University of Puerto Rico, San Juan, PR, USA

^g Department of Biostatistics and Epidemiology, Graduate School of Public Health, Medical Sciences Campus, University of Puerto Rico, San Juan, PR, USA

HIGHLIGHTS

- Rates of cardiovascular disease (CVD) and stroke have not decreased or have even increased among young adults compared with older adults.
- Cardiovascular health (CVH) in young adulthood predicts CVD outcomes in later years.
- Socioeconomically disadvantaged and minoritized groups experience worse CVH, especially at younger ages.
- In issuing its updated metric (Life's Essential 8, or LE8) to monitor the CVH of individuals and populations, the American Heart Association recommends further research to identify specific social determinants and psychological factors that are foundational to CVH.
- In a community sample of young adults in Puerto Rico, lower subjective social standing and elevated symptoms of anxiety and depression were the socioeconomic and psychological variables with the strongest associations with suboptimal (vs. ideal) CVH, as assessed by the LE8 metric.

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ABSTRACT

Objective: We aimed to determine the relationship between socioeconomic and psychological factors and overall cardiovascular health (CVH), as defined by the American Heart Association's Life's Essential 8 (LE8), among young adults in Puerto Rico.

Methods: Participants were 2156 young adults, between the ages of 18–29 years, enrolled in the PR-OUTLOOK study. The analysis included survey, laboratory, and physical measurement data collected from September 2020 to November 2023. Assessed socioeconomic indicators included food insecurity, housing instability, economic insecurity, and subjective social standing. Evaluated psychological factors comprised symptoms of depression, anxiety, post-traumatic stress, and overall perceived stress. LE8 scores were calculated and classified as suboptimal (poor/intermediate range) vs. ideal CVH. Logistic regression models estimated associations between each socioeconomic and psychological measure and suboptimal CVH, and dominance analysis assessed the importance of each measure.

Results: Participants' mean age was 22.6 (SD = 3.1), 60.9 % were female, about one-third (34.2 %) had high school education or less, and over one-third had public or no health insurance (38.4 %). Participants reporting socioeconomic adversity (i.e., high food insecurity, housing instability and economic insecurity, and low subjective social standing) and elevated psychological symptoms (i.e., symptoms of anxiety, depression, post-traumatic stress, and overall perceived stress) had lower CVH scores. However, in the adjusted analysis, only lower subjective social standing (OR = 1.38, 95 % CI = 1.13–1.69) and elevated symptoms of anxiety (OR =

* Corresponding author.

E-mail address: milagros.rosal@umassmed.edu (M.C. Rosal).

¹ These authors contributed equally to this work.

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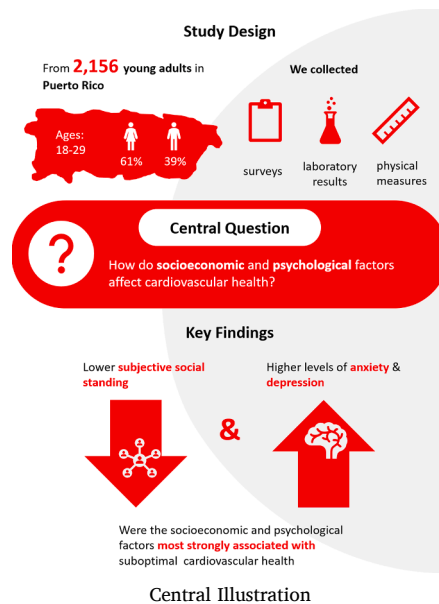
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1.63, 95 % CI = 1.25–2.13) and depression (OR = 1.30, 95 % CI = 1.03–1.65) emerged as the primary contributors to suboptimal CVH (vs. ideal).

Conclusion: Efforts to preserve and enhance CVH among young Puerto Ricans on the island should target these factors.



1. Introduction

Although cardiovascular disease (CVD) and stroke rates have decreased among older adults over time [1–3], they have either remained stable or even risen among younger individuals [4,5]. Furthermore, disparities in CVD incidence and prevalence persist, with Latino individuals experiencing higher CVD morbidity compared to White individuals [6–8]. Puerto Ricans, in particular, experience significant disparities in CVD, with a high prevalence of modifiable risk factors even in young adulthood [9–12].

The American Heart Association emphasizes the importance of preserving and enhancing cardiovascular health (CVH) across the life course and recently updated its metric for monitoring CVH from Life's Simple 7 (LS7) to Life's Essential 8 (LE8) [13]. CVH is associated with CVD morbidity and mortality, all-cause mortality, and non-CVD outcomes [13]. Higher CVH in young adulthood predicts lower CVD risk and mortality in later years [14] and improvements in CVH reduce risk [15–17]. Unfortunately, CVH declines with age, starting in adolescence [18], and socioeconomically disadvantaged and minoritized groups experience worse CVH [19], especially at younger ages. Thus, it is vital to pinpoint factors affecting CVH during young adulthood that can be targeted in interventions to optimize it.

Socioeconomic and psychological factors are foundational for CVH [17]. However, we must identify the most influential socioeconomic indicators and, similarly, the most influential psychological factors to effectively intervene to optimize CVH, particularly among populations most vulnerable to CVD, such as Puerto Ricans. Accordingly, in this study, we examined associations between key socioeconomic indicators and psychological factors and CVH, using the LE8 metric [13], among a community sample of young adults residing in Puerto Rico.

2. Methods

2.1. Sample

The sample includes young adults participating in the Puerto Rico Young Adults' Stress, Contextual, Behavioral & Cardiometabolic Risk (PR-OUTLOOK) study [20]. Eligibility criteria included: age 18 to 29; residence in Puerto Rico; born in Puerto Rico or to a Puerto Rican parent, or self-identifying as Puerto Rican; access to a telephone; no cognitive, psychiatric, or physical limitations to participate; not in active military service; and no immediate family member or partner already participating. The Institutional Review Board of the University of Puerto Rico Medical Sciences Campus protocol 6050319 approved the study.

PR-OUTLOOK methods were described elsewhere [20]. Briefly, starting in September 2020, participants were recruited from the US territory of Puerto Rico via island-wide public announcements (i.e., traditional and social media, and electronic and print advertisements), community outreach activities, and referrals. Study staff screened interested individuals, described study procedures, and obtained written consent. At baseline, participants completed a survey (online or by phone) and clinic visit. The analysis included participants who completed baseline assessment before November 2023.

2.2. Measures

2.2.1. Demographic factors

Participants completed questions about their age, sex at birth, marital status, educational attainment, student and work status, and health insurance type (private, government, or no insurance). Most participants were single, so the marital status categories were classified as unmarried (single, separated, divorced, and widowed) versus married/living with a partner.

2.2.2. Socio-economic measures

We assessed food insecurity [21] using the short form of the Household Food Security Scale, querying affordability, access, and availability of food in the household in the last 12 months. Scores 0–1 indicate high food security, 2–4 low food security, and 5–6 very low food security. Scores were dichotomized into food secure (score 0–1) and food insecure (score ≥ 2). This instrument has a sensitivity of 92 % and a specificity of 99.4 %.

Housing instability was assessed via two questions on: (1) experiences of having no place to live; and (2) concerns about the possibility of losing one's home or place to live temporarily in future months. Affirmative responses were summed (total range 0–2). A score ≥ 1 indicates housing instability.

Economic insecurity was assessed via a single item that asks respondents to consider all income contributed to their household and rate the difficulty of making ends meet. Responses range from 1 (very easy) to 5 (very difficult), with a score of ≥ 4 reflecting economic insecurity [22].

We used the MacArthur Scale for Subjective Social Standing [23], by which perceived social status relative to others in Puerto Rico is placed on a 10-rung pictorial "social ladder" (range 1–10), with higher scores indicating higher SSS. Scores were dichotomized into low (≤ 5) versus high (>5) based on the sample median. This measure has shown reliability and validity, and associations with CVH in Latino populations in the mainland US [24]. Given the age of our population, the SSS may be a more appropriate indicator of socioeconomic status among young adults

because usual indicators such as education and income are still evolving.

2.2.3. Psychological measures

Depression symptoms were assessed using the 10-item Center for Epidemiological Studies of Depression Scale [25], with experience of each of 10 symptoms over the past week rated on a four-point scale (total range 0–30). A score ≥ 10 reflects elevated depression symptoms. This scale has sound psychometric properties across various populations, including Latino groups [26,27].

For anxiety symptoms, we used the 10-item State-Trait Anxiety Inventory, with 10 symptoms rated on a four-point scale (range 10–40) [28]. As in previous studies [29,30], elevated anxiety was defined as scores \geq the sample distribution's highest quartile (27 for our sample). This scale exhibits sound internal consistency and factorial validity with Latino populations [27].

We used the Abbreviated Post-Traumatic Stress Disorder Checklist for Civilians to assess post-traumatic stress [31]. Two items assess the experience of being bothered by memories, thoughts or images of a stressful experience, and its severity. A score ≥ 4 indicates significant symptoms of post-traumatic stress. This scale correlates well with the original scale on the Composite International Diagnostic Interview Version 2.1, with sound sensitivity and specificity [31].

We also used the Cohen Perceived Stress Scale-4 [32], where the frequency of feeling stressed or unable to control life challenges over the past month is rated on a 5-point scale. A score ≥ 6 reflects high perceived stress. This scale has had high internal consistency and construct validity across various populations [33–35].

2.2.3.1. Outcome variable: cardiovascular health (CVH). Overall CVH was assessed using the LE8 metric, which consists of an unweighted average of 4 behavioral (nicotine exposure, physical activity, diet quality, and sleep duration) and 4 physiological (blood pressure, glucose, non-HDL cholesterol, and body mass index) metrics, each with a defined scoring algorithm [13]. Ideal CVH scores range from 0 to 100, with scores categorized as poor (0–49), intermediate (50–79), and ideal (80–100). The number of participants in the three CVH categories was unevenly distributed, with only 3.5 % falling into the “poor” category. Thus, we defined suboptimal CVH as having a score in the poor or intermediate category and compared this suboptimal category with the ideal CVH category. Methods for data collection for calculating the LE8 score are described below.

Nicotine exposure was self-reported and included current and past use of combustible cigarettes, inhaled nicotine delivery systems (e-cigarettes), and secondhand smoke [36,37]. Physical activity was assessed via a 9-item survey with questions about frequency and duration of leisure-time walking and other light, moderate, and vigorous physical activity over the past seven days [38,39]. Diet in the past year was measured with a Food Frequency Questionnaire adapted and validated for Puerto Ricans living on the island [40,41], using the Nutrition Data System for Research (University of Minnesota, Minneapolis, MN). Diet quality scores were calculated using the Mediterranean Eating Pattern for Americans tool [42]. Sleep duration was assessed using the Sleep Heart Health Study tool [43], a 2-item survey designed to measure the timing of falling asleep and waking up on weekends and weekdays.

Body mass index was calculated from height and weight (weight (kg)/height (m) [2]), both measured by trained research staff using standardized protocols [44]. Height was measured using a SECA 213 portable stadiometer and rounded to the nearest centimeter. Weight was measured with a Tanita WB800-S Plus Digital Scale and rounded to the nearest tenth kilogram. Three systolic and diastolic blood pressure measures were taken at two-minute intervals with a digital automatic blood pressure monitor (Omron HEM-907XL) after a ten-minute rest in a sitting position and using an appropriately sized cuff on the participant's right arm (we averaged the three measures). Blood glucose and non-HDL cholesterol were assessed from blood samples collected by a certified

phlebotomist. Serum concentrations of total cholesterol, high-density lipoprotein cholesterol (HDL-C), triglycerides, and blood glucose were assayed by the analyzer ARCHITECT Clinical Chemistry System (Abbott Core Laboratories, Lake Forest, IL). Non-HDL-C was computed as the difference in total cholesterol and HDL-C. Glycosylated hemoglobin was assessed using a Tosoh Automated Glycohemoglobin Analyzer G8 (Tosoh Bioscience, Inc., South San Francisco, CA).

2.2.4. Statistical analysis

Analyses include data collected between September 2020 and November 2023, during which 2192 participants completed their baseline assessment. We excluded participants based on pregnancy status at the time of the clinic visit ($n = 4$) and missing data: education ($n = 2$), work status ($n = 1$), insurance type ($n = 14$), and measures of depressive symptoms ($n = 2$), post-traumatic stress ($n = 2$), housing instability ($n = 3$), economic insecurity ($n = 1$), and subjective social standing ($n = 5$). The final analytic sample included 2156 participants.

We examined participants' demographic characteristics according to socioeconomic and psychological factors using chi-square tests for categorical variables and Student's *t*-tests for continuous variables. The adjusted means for the overall CVH score and corresponding 95 % confidence intervals (95 % CI) for each factor were estimated using linear regression. Simple and multivariable binary logistic regression estimated the associations between categorical CVH scores (suboptimal (i.e., poor/intermediate) vs. ideal) and each socioeconomic and psychological measure

All models were adjusted for age, sex, marital status, educational level, and health insurance type. The models for psychological factors were additionally adjusted for subjective social status, an appropriate socioeconomic indicator for young adults because education, work status, and income during this phase of life may still evolve [45,46]. Odds Ratios (OR) estimated the odds of having suboptimal (poor or intermediate) CVH vs. ideal CVH.

Finally, we employed dominance analysis in separate logistic regression models to assess the relative importance of each socioeconomic and psychological factor in explaining suboptimal (vs. ideal) CVH based on variance decomposition [47]. The unstandardized general dominance statistic represents the average additional variance each independent variable uniquely explains across all subset models, the standardized dominance statistic represents the percentage of the overall model fit, summing to 100 %, and the dominance ranking defines the rank order of the independent variables based on their dominance statistics. For the purpose of our analysis, socioeconomic and psychological factors with higher dominance scores in the multivariable logistic regression model were considered more influential in explaining suboptimal CVH. Statistical significance was determined at the 5 % level. Dominance analysis offers advantages over traditional methods by evaluating all possible subsets of independent variables and assessing their incremental contributions to the model's fit statistic (McFadden pseudo-R [2]) while accounting for their potential correlations. The analysis used the 'domin' function in Stata version 18 (StataCorp, College Station, TX, USA), which computes both the unstandardized and standardized dominance statistics and the dominance ranking [48].

3. Results

3.1. Demographic characteristics

Our sample of 2156 young Puerto Rican adults had a mean age of 22.6 years (SD = 3.1), over half were female (60.9 %), most were unmarried (87 %), slightly over one-third (34.2 %) had a high school education or less, half were employed (50.1 %), almost half (46 %) were full-time students (working or not working), and over one-third had public health insurance or no insurance (35.7 % and 2.7 %, respectively).

3.2. Socioeconomic factors

A total of 24 % of the sample reported food insecurity, 17 % reported housing instability, 29.7 % reported economic insecurity, and 59.3 % reported low subjective social standing. Table 1 shows significant differences between high and low socio-economic indicators based on education and insurance type across all socio-economic indicators. Furthermore, differences by marital status were observed for food insecurity and housing instability, while differences by sex were evident in food insecurity.

Participants with high food insecurity, housing instability and economic insecurity scores (vs. low) and those with low subjective social standing (vs. high) had significantly higher CVH scores (Fig. 1). Logistic regression models showed that only low scores in subjective social standing significantly increased the odds of having a suboptimal (vs. ideal) CVH score after controlling for age, sex, marital status, educational attainment, and health insurance (Table 2, Model 2). This association persisted after controlling for the effect of food insecurity, housing instability and economic insecurity, with low subjective social standing increasing the odds of having suboptimal (vs. ideal) CVH by 36 % (Model 3). The results of dominance analysis for the socio-economic indicators showed that, compared to food insecurity, housing instability and economic insecurity, subjective social standing, was the most influential factor for suboptimal CVH, accounting for 69 % of the predicted variance.

3.3. Psychological factors

Nearly 58.7 % of participants had elevated symptoms of depression, 27.1 % had elevated anxiety, 64.5 % had high perceived stress, and 77.4 % had symptoms of post-traumatic stress. Table 3 shows demographic characteristics and psychological symptom scores. There were significant differences in depression symptoms and perceived stress scores by age. All psychological symptom scores exhibited significant differences based on sex and subjective social status. Additionally, depression, anxiety and perceived stress scores differed by education level, while post-traumatic stress scores differed by marital status.

Participants with elevated symptoms of depression, anxiety, post-traumatic stress, and perceived stress had significantly lower adjusted CVH scores compared to those with low psychological symptom scores (Fig. 2). Logistic regression models showed that high scores on all the psychological measures were associated with greater odds of having a suboptimal CVH (poor/intermediate vs. high) score after controlling for age, sex, marital status, educational attainment, and subjective social standing (Table 4, Model 2). However, after additionally controlling for

the effect of the other psychological factors (Model 3), only elevated scores in anxiety and depressive symptoms remained significantly associated with greater odds of suboptimal CVH, with elevated anxiety increasing the odds by 65 % and elevated depressive symptoms increasing the odds by 30 %. Findings from dominance analysis indicate that anxiety and depression scores were the most important influential psychological factors for suboptimal CVH, accounting for 46 % and 30 % of the predicted variance in CVH, respectively.

4. Discussion

We investigated associations between selected socioeconomic and psychological factors and overall CVH among young adults in Puerto Rico, addressing the need to identify key determinants for achieving optimal CVH [13]. To our knowledge, this is the first study to examine these questions among a large cohort of young or Latino individuals and the first to use the updated CVH (LE8) metric. The study focused on Puerto Ricans residing in Puerto Rico, an understudied population with well-documented CVD disparities [9–12].

Findings for our examined socioeconomic indicators showed that individuals with high food insecurity, housing instability and economic insecurity and lower subjective social standing had significantly lower CVH scores than those with no food insecurity, housing instability and economic insecurity, or high subjective social standing. However, only subjective social standing emerged as the dominant factor associated with suboptimal (vs. ideal) CVH, with those in the lower half of the ladder having greater odds of experiencing suboptimal CVH. While few studies have examined the associations among these variables and CVH score, findings are consistent with a broader literature showing that other unfavorable socioeconomic conditions are associated with CVH as well as risk, prevalence, and mortality from CVD [49–56].

Among 6453 adults aged 45–84 participating in the Multi-Ethnic Study of Atherosclerosis, those "experiencing ongoing financial strain" (a construct related to economic insecurity) had lower odds of ideal LS7 CVH scores [57]. In other studies, the number of socioeconomic adversity factors was associated with CVH. For example, NHANES data (1999–2006) [58] showed that as the exposure to a higher number of adverse socioeconomic factors (including income and education) increased, the likelihood of having a CVH metric in the ideal range decreased. Similarly, the Hispanic Community Health Study/Study of Latinos found that a higher number of adversity factors (including income <\$20,000 and < high school education) was associated with several CVD risk factors and risk of stroke among Latino participants [59]. Perceptions of one's socioeconomic circumstances, rather than the ability to attain resources, may be a powerful factor in accounting for

Table 1
Sample demographic characteristics by socio-economic indicators,¹ PR-OUTLOOK, 2020–2023 (n = 2156).

	Food insecurity n (%) or mean (SD)			Housing instability n (%) or mean (SD)			Economic insecurity n (%) or mean (SD)			Subjective social standing n (%) or mean (SD)		
	High n = 518	Low n = 1638	P value	High n = 367	Low n = 1789	P value	High n = 640	Low n = 1516	P value	High n = 877	Low n = 1279	P value
Age	22.9 ± 3.0	22.6 ± 3.1	0.06	23.5 ± 3.1	22.4 ± 3.1	<0.001	22.7 ± 3.1	22.6 ± 3.1	0.42	22.7 ± 3.2	22.6 ± 3.1	0.46
Sex: female	341 (65.8)	972 (59.4)	0.01	234 (63.8)	1079 (60.3)	0.22	395 (61.7)	918 (60.6)	0.62	525 (59.9)	788 (61.6)	0.43
Marital status: not married	431 (83.2)	1457 (89.0)	0.001	290 (79.0)	1598 (89.3)	<0.001	548 (85.6)	1340 (88.4)	0.07	782 (89.2)	1106 (86.5)	0.06
Education: high school or less	171 (33.0)	568 (34.7)	0.001	97 (26.4)	641 (35.8)	<0.001	222 (34.7)	516 (34)	<0.001	276 (31.5)	462 (36.1)	<0.001
Health insurance: public or none	271 (52.3)	555 (33.9)	<0.001	208 (56.7)	617 (34.5)	<0.001	336 (52.5)	489 (32.3)	<0.001	258 (29.4)	567 (44.3)	<0.001

¹ Socio-economic indicators: Food insecurity was assessed using the short form of the Household Food Security Scale (high defined as a score ≥2). Housing instability assessed by two questions: one assessing the experience of having no place to live and another about current concerns about the possibility of losing one's home or place to live temporarily in the future months (high defined as a score ≥1). Economic insecurity was assessed by an item that asks respondents to consider all income contributed to their household and rate the difficulty of making ends meet (high defined as a score ≥4). Subjective social standing as assessed by the MacArthur Scale of Subjective Social Standing (low defined as a score ≤5).

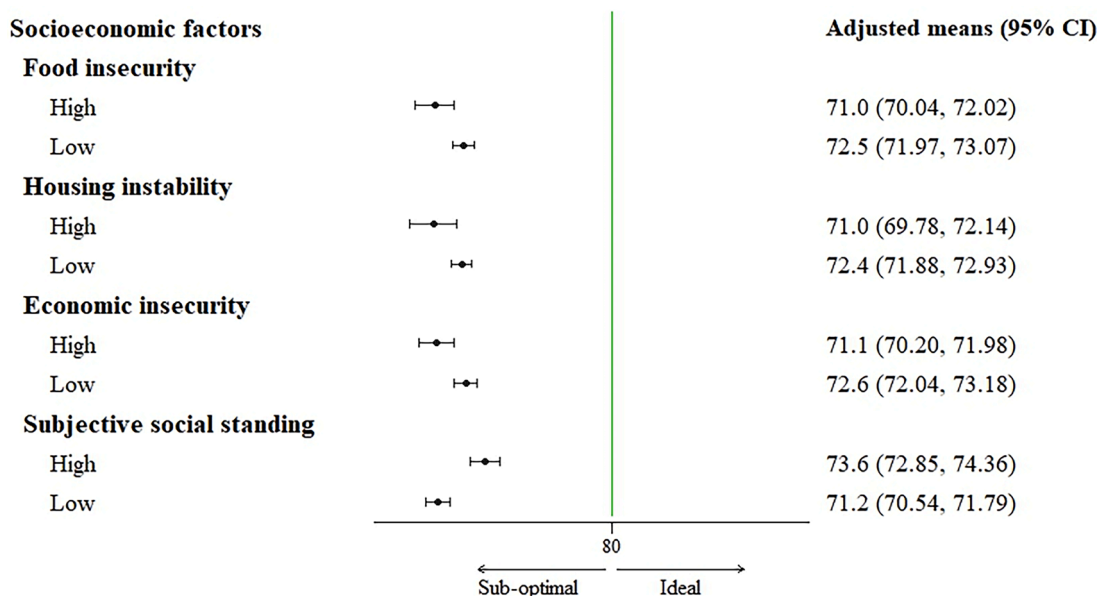


Fig. 1. Adjusted means of CVH score according to socio-economic indicators,¹ PR-OUTLOOK 2020–2023 (n = 2156)
¹Socio-economic indicators: Food insecurity was assessed using the short form of the Household Food Security Scale (high defined as a score ≥ 2). Housing instability assessed by two questions: one assessing the experience of having no place to live and another about current concerns about the possibility of losing one’s home or place to live temporarily in the future months (high defined as a score ≥ 1). Economic insecurity was assessed by an item that asks respondents to consider all income contributed to their household and rate the difficulty of making ends meet (high defined as a score ≥ 4). Subjective social standing as assessed by the MacArthur Scale of Subjective Social Standing (low defined as a score ≤ 5).
²Mean scores were adjusted for age, sex, marital status, educational level, and health insurance type.

CVH among young adults CVH [56,60]. Subjective social standing is thought to reflect a "cognitive averaging" of a person’s socioeconomic situation [61] and may capture unique aspects of social and economic conditions (i.e., social status experiences over the life course) missed by other socioeconomic status indicators [62,63].

Our findings are also interesting in light of studies that found that associations between subjective social standing and CVD risk are strongest among White compared to non-White samples [46,56]. Such differences are hypothesized to result from different groups considering different socioeconomic factors in arriving at their subjective social status ranking [46]. Future studies are warranted to understand what factors young adults consider in evaluating their subjective social standing ranking (i.e., parental socioeconomic status). Improving this understanding among young adults in PR may provide a greater understanding of factors to target in future clinical and public health interventions to optimize CVH.

Findings for the examined psychological factors showed that participants with elevated symptoms of depression, anxiety, post-traumatic stress, or perceived stress had lower CVH scores compared to those with no elevated symptoms. We also observed that elevated anxiety and depression symptoms increased the odds of suboptimal CVH (vs. ideal), with results of dominance analysis showing elevated anxiety symptoms as the most important psychological factor associated with suboptimal CVH, followed by elevated depression symptoms.

These findings are consistent with studies of associations between anxiety and depression symptoms and the old CVH metric (LS7). Two previous studies included but did not report data specific to young adults. The first one used a sample of 875 primarily White U.S. adults aged 18–35 years and found that elevated symptoms of anxiety and depression were significantly associated with lower LS7 scores [64]. The second study used Behavioral Risk Factor Surveillance System data (2017–2020) from individuals aged 18–49 years (n = 593,616) and found that individuals with depressive symptoms had higher odds of suboptimal CVH defined as ≥ 2 of 7 CVD risk factors [65].

Our findings also align with studies conducted with middle-aged and older populations in the U.S. and other countries. Of high relevance to

our study, findings from CARDIA [66] with a sample of 3614 non-Hispanic Black and White U.S. young adults who were followed for 20 years, showed a significant association between worsening depressive symptoms and LS7 CVH scores. A study of 9962 Chinese individuals (mean age 47.1 years) reported inverse associations between symptoms of depression, anxiety, and stress and the number of ideal CVH metrics [67], and a study of 732 Finnish women (mean age 48 years) similarly reported an inverse association between symptoms of depression, but no anxiety, and number of ideal CVH metrics [68]. Finally, a Brazilian study that examined the association between clinically diagnosed depressive and anxiety disorders (rather than survey-assessed elevated symptoms) and CVH found that having a diagnosis of either disorder was associated with higher odds of poor and intermediate CVH among 13,743 middle-aged and older individuals [69]. We are unaware of studies that have examined associations between symptoms of post-traumatic stress and CVH. Overall, our findings confirm literature from various other populations suggesting that anxiety and depression may be key to understanding suboptimal CVH.

A large proportion of participants in this community sample of young Puerto Rican adults experienced elevated psychological symptoms. Findings of elevated depressive symptoms in 58.7 % of our sample are in contrast to a 2013 study where 9 % of a sample of Puerto Rican college students reported elevated depressive symptoms [70], but aligned with a recent study where approximately half of medical and nursing students reported mild-to-severe depressive symptoms [71]. Limited data for symptoms of anxiety, post-traumatic stress, or perceived stress are available for young adults aged 18–29 years in Puerto Rico; however, a study of Puerto Rican adults aged 30–75 observed that 21.5 %, 32 %, and 31.4 % of participants had elevated symptoms of anxiety, post-traumatic stress, and depression, respectively [72]. The Puerto Rican population on the island has been exposed to numerous environmental stressors, including Hurricane María in 2017 and the 6.4 magnitude earthquake and subsequent series of tremors in 2020. These events led to deaths, material losses and displacement of the population, and have been associated with elevated symptoms of depression, anxiety, and post-traumatic stress in studies of adults and children [72,73]. It

Table 2
Suboptimal (poor/intermediate) vs. ideal CVH by socio-economic indicators, PR-OUTLOOK, 2020–2023 (n = 2156).

Socio-economic indicators ¹	Model 1 ²	Model 2 ³	Model 3 ⁴	Standardized Dominance Statistic ⁵	Dominance Ranking ⁶
	OR (95 % CI)	OR (95 % CI)	OR (95 % CI)		
Food insecurity: High vs. Low	1.3 (1.04, 1.64) P = 0.02	1.23 (0.97, 1.55) P = 0.08	1.12 (0.86, 1.45) P = 0.39	0.1261	2
Economic insecurity: High vs. Low	1.27 (1.03, 1.57) P = 0.03	1.17 (0.94, 1.46) P = 0.15	1.04 (0.82, 1.32) P = 0.76	0.1098	3
Housing instability: High vs. Low	1.26 (0.97, 1.63) P = 0.09	1.17 (0.89, 1.52) P = 0.26	1.06 (0.81, 1.41) P = 0.65	0.0707	4
Subjective social standing: Low vs. High	1.5 (1.24, 1.82) P < 0.001	1.42 (1.17, 1.73) P < 0.001	1.38 (1.13, 1.69) P = 0.001	0.6934	1

¹ Socio-economic indicators: Food insecurity was assessed using the short form of the Household Food Security Scale (high defined as a score ≥ 2). Housing instability assessed by two questions: one assessing the experience of having no place to live and another about current concerns about the possibility of losing one's home or place to live temporarily in the future months (high defined as a score ≥ 1). Economic insecurity was assessed by an item that asks respondents to consider all income contributed to their household and rate the difficulty of making ends meet (high defined as a score ≥ 4). Subjective social standing as assessed by the MacArthur Scale of Subjective Social Standing (low defined as a score ≤ 5).

² Model 1: unadjusted logistic regression model (odds ratios and 95 %CI).

³ Model 2: Model 1 adjusted for age, sex, marital status, educational attainment, and health insurance;

⁴ Model 3: Model 2 additionally adjusted for the other socioeconomic indicators.

⁵ The standardized dominance statistic expresses the general dominance statistic value as a percentage of the overall fit statistic value and thus sums to 100 %.

⁶ The dominance ranking provides a rank ordering of the economic indicators based on their general dominance statistics.

is also important to note that our study assessments occurred between November 2020 and June 2023, a time when anxiety and depression spiked due to the COVID-19 pandemic, particularly among youth [74–78] and those with pre-existing symptoms of depression and anxiety [79].

In contrast, the finding that 24 % of our sample reported food insecurity was lower than the ranges of 27.3 % to 40 % previously reported [80], except for one community sample of 865 individuals aged 30–70 years where the frequency of food insecurity was 20.3 % [81]. We are unaware of prior reports of housing instability or economic insecurity as defined in this study. However, our findings that almost 30 % of the sample experienced difficulty "to make ends meet" are consistent with economic data on the island, which points to high unemployment rates, low annual income, and a two-decade period of economic decline [82].

Our study has several limitations. First, while we recruited participants from across Puerto Rico, the sample does not fully represent the young adult population aged 18–29 living on the island. Our sample had a slight overrepresentation of women and individuals with less than a high school education, and a slight underrepresentation of unmarried individuals and those with public or no health insurance, potentially limiting the generalizability of our findings. In addition, as socioeconomic and psychological factors may operate differently based on place of origin and place of residence [83], findings from this sample may not apply to other young adults or other Latino groups, including other young Puerto Ricans residing in the mainland U.S. Second, the analysis included only a selected group of psychological factors and socioeconomic indicators. Still, the factors studied are of considerable interest in defining the socioeconomic and psychological determinants of CVH. Finally, the cross-sectional nature of this study precludes attribution of causality, and the direction of the association could not be examined. Longitudinal studies should explore the cumulative impact of these variables on the long-term preservation or deterioration of CVH. CARDIA reported a significant effect of trajectories of depressive symptoms on CVH [66]; however, CARDIA focused on Black and White individuals, and no data exist for Hispanic/Latino young adults. Moreover, future studies should explore the potential bidirectional associations between socioeconomic and psychological factors and CVH [84, 85].

Our study also has several strengths. This study is the first to examine socioeconomic and psychological factors and CVH among young adults using the recently updated LE8 definition of CVH. We calculated the metric using rigorous measurement protocols and following the proposed LE8 algorithms. Previous studies have used the LS7 metric, made modifications to the metric, or used self-reported data, which limits comparisons across studies. We focus on Puerto Ricans, a population

Table 3
Sample demographic characteristics by psychological factors,¹ PR-OUTLOOK, 2020–2023 (n = 2156).

	Depression symptoms n (%)			Anxiety symptoms n (%)			Perceived stress n (%)			Post-traumatic stress symptoms n (%)		
	High n =	Low n =	P value	High n =	Low n =	P value	High n =	Low n =	P value	High n =	Low n =	P value
	1266	890		586	1570		1392	764		1668	488	
Age, y	22.5 ± 3.1	22.8 ± 3.1	0.03	22.6 ± 3.1	22.6 ± 3.1	0.64	22.5 ± 3.0	22.8 ± 3.2	0.02	22.6 ± 3.1	22.8 ± 3.2	0.24
Sex: female	841 (66.4)	472 (53.0)	<0.001	414 (70.7)	899 (57.3)	<0.001	930 (66.8)	383 (50.1)	<0.001	1056 (63.3)	257 (52.7)	<0.001
Marital status: not married	1116 (88.2)	772 (86.7)	0.33	517 (88.2)	1371 (87.3)	0.58	1223 (87.9)	665 (87)	0.60	1479 (88.7)	409 (83.8)	0.004
Education: high school or less	445 (35.2)	293 (32.9)	0.002	192 (32.8)	546 (34.8)	0.001	503 (36.1)	235 (30.8)	0.002	576 (34.5)	162 (33.2)	0.80
Subjective social standing: ≤ 5	454 (35.9)	423 (47.5)	<0.001	409 (69.8)	870 (55.4)	<0.001	886 (63.7)	393 (51.4)	<0.001	1027 (61.6)	252 (51.5)	<0.001
Public or no health insurance	495 (39.1)	330 (37.1)	0.33	220 (37.5)	605 (38.5)	0.66	542 (39.0)	283 (37)	0.38	635 (38.1)	190 (39)	0.74

¹ Psychological factors: Depressive symptoms assessed by the Center for Epidemiological Studies Depression Scale-10 (high defined as a score ≥ 10). Anxiety symptoms assessed by Spielberger Trait Anxiety Scale-10 (high defined as a score ≥ 27). Perceived stress assessed by the Cohen Perceived Stress Scale-4 (high defined as a score ≥ 6). Post-traumatic stress symptoms assessed by the Abbreviated Civilian Post-Traumatic Stress Disorder Checklist-2 (high defined as a score ≥ 4).

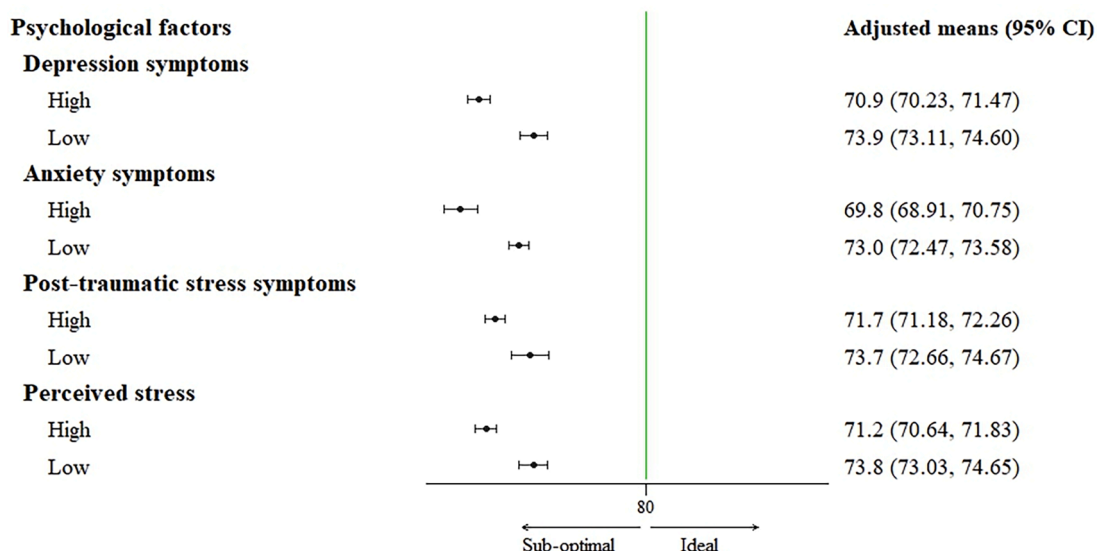


Fig. 2. Adjusted means of CVH score according to psychological factors,¹ PR-OUTLOOK 2020–2023 (n = 2156)

¹Psychological factors: Depressive symptoms assessed by the Center for Epidemiological Studies Depression Scale-10 (high defined as a score ≥ 10). Anxiety symptoms assessed by the Spielberger Trait Anxiety Scale-10 (high defined as a score ≥ 27). Perceived stress assessed by the Cohen Perceived Stress Scale-4 (high defined as a score ≥ 6). Post-traumatic stress symptoms assessed by the Abbreviated Civilian Post-Traumatic Stress Disorder Checklist-2 (high defined as a score ≥ 4).

²Mean scores were adjusted for age, sex, marital status, educational level, health insurance type, and subjective social standing.

Table 4

Suboptimal (poor/intermediate) vs. ideal CVH by psychological factors, PR-OUTLOOK, 2020–2023 (n = 2156).

Psychological factors ¹	Model 1 ² OR (95 % CI)	Model 2 ³ OR (95 % CI)	Model 3 ⁴ OR (95 % CI)	Standardized Dominance Statistic ⁵	Dominance Ranking ⁶
Depressive symptoms: High vs. Low	1.68 (1.39, 2.03) P < 0.001	1.71 (1.4, 2.08) P < 0.001	1.30 (1.03, 1.65) P = 0.03	0.3018	2
Anxiety symptoms: High vs. Low	1.97 (1.56, 2.49) P < 0.001	2.02 (1.59, 2.56) P < 0.001	1.63 (1.25, 2.13) P < 0.001	0.4477	1
Perceived stress: High vs. Low	1.54 (1.27, 1.87) P < 0.001	1.58 (1.29, 1.93) P < 0.001	1.15 (0.91, 1.45) P = 0.25	0.1608	3
Post-traumatic stress symptoms: High vs. Low	1.43 (1.15, 1.77) P = 0.001	1.46 (1.17, 1.83) P = 0.001	1.18 (0.93, 1.49) P = 0.17	0.0897	4

¹ Psychological factors: Depressive symptoms assessed by the Center for Epidemiological Studies Depression Scale-10 (high defined as a score ≥ 10). Anxiety symptoms assessed by the Spielberger Trait Anxiety Scale-10 (high defined as a score ≥ 27). Perceived stress assessed by the Cohen Perceived Stress Scale-4 (high defined as a score ≥ 6). Post-traumatic stress symptoms assessed by the Abbreviated Civilian Post-Traumatic Stress Disorder Checklist-2 (high defined as a score ≥ 4).

² Model 1: unadjusted logistic regression model (odd ratios and 95 %CI);

³ Model 2: Model 1 adjusted for age, sex, marital status, educational attainment, health insurance, and subjective social standing.

⁴ Model 3: Model 2 additionally adjusted for the other psychological factors.

⁵ The standardized dominance statistic expresses the general dominance statistic value as a percentage of the overall fit statistic value and thus sums to 100 %.

⁶ The dominance ranking provides a rank ordering of the economic indicators based on their general dominance statistics.

that is overrepresented in CVD risk but underrepresented in CVH and CVD prevention research. Our findings constitute an important contribution to the scarcity of data on what and to what extent socioeconomic and psychological factors may contribute to suboptimal CVH among young adults on the island.

In conclusion, this paper confirms that selected socioeconomic and psychological factors, namely elevated anxiety and depressive symptoms and lower subjective social standing, increase the odds of experiencing poor/intermediate CVH. Efforts to preserve and optimize CVH among young adults in Puerto Rico will need to address these factors, as the experience of anxiety and depressive states may be a major barrier to health behavior change, and lower subjective social standing may reflect socioeconomic challenges associated with less healthy behaviors (e.g., lower health literacy, limited access to nutritious foods and walking/recreational spaces). Given the ongoing increase of CVD in younger adults and the strong association between CVH in young adults and CVD risk in later years, primordial prevention of CVH in this population is critically important.

Ideal CVH status and modest improvements in CVH metrics can substantially reduce the risk of CVD events and CVD-related mortality [86,87]. Our findings point to the need for interventions to optimize CVH among young adults in PR. In recognition that many young adults do not seek primary care regularly, innovative public health approaches to intervene with this population are needed to increase awareness of CVH and screen and intervene with factors that contribute to its decline. Efforts to address psychological symptoms and SSS in young Puerto Ricans may improve CVH and reduce the burden of CVD in this high-risk population in later years. Lastly, studies are warranted to understand further the biological pathways by which psychological states and socioeconomic factors contribute to unfavorable CVH and vice versa.

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The sponsor had no role in the study with regards to design; data collection, analysis or interpretation; or writing of this article.

Data availability

The deidentified PR-OUTLOOK dataset corresponding to this

analysis is available upon request for the purpose of examining the reproducibility of our findings. Requests are subject to review and approval from the Institutional Review Boards of the University of Puerto Rico and the University of Massachusetts Chan Medical School.

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Author agreement

On behalf of our writing team, I certify that each author has seen and approved the final version of the manuscript being submitted. The work we are submitting is the authors' original work, hasn't received prior publication and isn't under consideration for publication elsewhere.

CRediT authorship contribution statement

Milagros C. Rosal: Writing – review & editing, Writing – original draft, Supervision, Methodology, Funding acquisition, Conceptualization. **Israel Almodóvar-Rivera:** Visualization, Formal analysis. **Sharina D. Person:** Writing – review & editing, Formal analysis. **Andrea López-Cepero:** Writing – review & editing. **Catarina I. Kiefe:** Writing – review & editing, Funding acquisition, Conceptualization. **Katherine L. Tucker:** Writing – review & editing, Methodology. **Maria Uribe-Jerez:** Writing – review & editing. **José Rodríguez-Orengo:** Writing – review & editing. **Cynthia M. Pérez:** Writing – review & editing, Supervision, Methodology, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Milagros C. Rosal reports financial support was provided by National Heart Lung and Blood Institute. If there are other authors, they 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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