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Association of Acculturation with Cardiac Structure and Function among Hispanic/Latinos: the Echocardiographic Study of Latinos

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Association of Acculturation with Cardiac Structure and Function among Hispanic/Latinos: the Echocardiographic Study of Latinos

Short Title: Acculturation and Cardiac Structure and Function

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Strengths and limitations of this study

- A population-based cohort study among predominantly immigrant Hispanic/Latinos in the United States.
- A detailed comprehensive echocardiographic examination was used to determine cardiac structure and function in every participant.
- Determined whether sociocultural factors, such as acculturation contribute to the heart failure risk factor burden among an immigrant population.
- We are specifically referring to acculturation into the US culture which may not be generalizable to acculturation in other settings.

For peer review only

Abstract

Background: Hispanics/Latinos, the largest immigrant population in the US, have a large burden of heart failure risk. There is a paucity of research regarding the impact of acculturation on cardiac structure and function.

Methods: In the Echocardiographic Study of Latinos, 1,818 Hispanic adult participants underwent assessment of left atrial volume index (LAVI), left ventricular mass index (LVMI), early diastolic transmitral inflow and mitral annular velocities. Acculturation was measured by the Short Acculturation Scale, nativity, immigration age, length of US residence, generation status, and language.

Results: The study population was predominantly Spanish-speaking and foreign-born with mean US residence of 22.7 years, mean age of 56.4 years; 50% had hypertension, 28% had diabetes, and 44% had a BMI >30kg/m². Multivariable analyses demonstrated higher LAVI with increasing years of US residence. Foreign-born and first generation participants had higher E/e' but lower LAVI and e' velocities compared to the second generation. Higher acculturation and income >\$20K were associated with higher LVMI, LAVI, and E/e', but lower e' velocities. Preferential Spanish-speakers with an income <\$20K had a higher E/e'.

Conclusions: Acculturation was associated with abnormal cardiac structure and function, with some effect modification seen according to socioeconomic status.

Abstract Word Count: 193

Keywords: Acculturation, Echocardiogram, Hispanics/Latinos, Socioeconomic Status

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3 Cardiovascular disease (CVD) and heart failure (HF) risk factor burden is high among
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5 Hispanic/Latinos in the United States (US)¹ leading to abnormalities of cardiac structure and
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7 function² which have been associated with incident clinical HF,³ incident CVD and increased
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9 mortality.⁴⁻⁷
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14 With respect to HF, Hispanics/Latinos have a higher incidence of HF compared to Non-Hispanic
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16 Whites and Hispanics/Latinos who present with HF are younger with more co-morbidities and a
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18 lower left ventricular ejection fraction.⁸⁻¹⁰ Beyond traditional HF risk factors, unique
19
20 sociocultural factors such as acculturation, may contribute to HF risk among Hispanic/Latinos
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22 **(Figure/Conceptual Model).**⁹ The fact that Hispanics/Latinos are the largest immigrant
23
24 population in the US affords the ideal opportunity to study the impact of acculturation on cardiac
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26 parameters. Acculturation is a multidimensional process whereby an immigrant culture adopts
27
28 the beliefs and practices of a host culture with both positive and negative effects that may
29
30 differentially influence CVD development.¹¹ Higher acculturation has been associated with
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32 increased psychosocial stress, deleterious cardiovascular health behaviors and a higher CV risk
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34 factor burden.¹²⁻¹⁴ To our knowledge, there is only one prior study¹⁵ demonstrating that lower
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36 acculturation was associated with a greater risk of HF re-hospitalization.
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45 We sought primarily to test whether acculturation, as an important bio-sociocultural variable, is
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47 associated with cardiac structure and function among Hispanics/Latinos. Studies often overlook
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49 socioeconomic status (SES) as an interconnected correlate with acculturation. Because SES is
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51 associated with cardiac parameters¹⁶ and modifies the association between acculturation and
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3 other health-related variables,¹⁷ secondarily, we sought to test whether our primary associations
4 are moderated by SES.
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10 **Methods**

11 **Cohort Description**

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13 The Hispanic Community Health Study/Study of Latinos (HCHS/SOL) is a population-based
14 study of 16,415 Hispanic/Latinos from randomly selected households at four US field centers
15 (Bronx, NY; Chicago, IL; Miami, FL; and San Diego, CA).¹⁸ Probability sampling was used to
16 ensure broad representation of the target population and to minimize the sources of bias that may
17 otherwise enter into the cohort selection and recruitment process. Participants were between 18
18 and 74 years of age, and self-identified as Cuban, Central American, Dominican, Mexican,
19 Puerto Rican, or South American Hispanic/Latino heritage. The ECHO-SOL ancillary study was
20 designed to provide echocardiographic parameters characterizing cardiac structure and function
21 in a representative HCHS/SOL baseline subsample of 1,818 participants ≥ 45 years old.^{2,19} The
22 Institutional Review Board approval was obtained at each study site and oversight of all study all
23 ECHO-SOL participants gave informed consent.
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43 **In-Person Examination**

44 The examination protocol for the parent HCHS/SOL has been previously published.¹² Obesity
45 was defined as a body mass index (BMI) ≥ 30.0 kg/m². Seated resting blood pressures were
46 measured in triplicate and the average of the 2nd and 3rd readings was used for analysis. Type 2
47 diabetes was defined based on American Diabetes Association definition using one or more of
48 the following criteria: 1) fasting serum glucose ≥ 126 mg/dl, 2) oral glucose tolerance test ≥ 200
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3 mg/dl, 3) self-reported diabetes, 4) Hb A1C \geq 6.5%, or 5) taking anti-diabetic medication or
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5 insulin. Renal function was measured by estimated glomerular filtration rate (eGFR). Physical
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7 activity levels, categorized as low or medium/high, were assessed using the Global Physical
8
9 Activity Questionnaire.²⁰ Self-report questionnaires assessed smoking status (no/ever/current),
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11 alcohol consumption (current/no), and insurance coverage (yes/no) and type
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13 (Private/Medicare/Medicaid). Socioeconomic status was defined as highest degree or level of
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15 school completed and household income level – dichotomized as $<$ \$20,000 and $>$ \$20,000, given
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17 the low number of participants with incomes $>$ \$40,000. Our secondary analysis focused on
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19 income rather than education because education was completed prior to migration for most
20
21 immigrants in our study population and current income while living in the US may more
22
23 relevantly impact on a participant's acculturative process, acting as a proxy for the participant's
24
25 ability to integrate and be exposed to mainstream US contexts. Marital status categorized as
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27 (single/married/partnered/separated/divorced/widowed).
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35 **Primary Echocardiographic Measurements**

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37 Trained sonographers performed transthoracic echocardiography examinations, including 2D
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39 imaging, and spectral, color and tissue Doppler.¹⁹ The following measured and derived cardiac
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41 variables utilized in this study were: left ventricular mass index (LVMI), relative wall thickness
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43 (RWT) and LV Ejection Fraction (LVEF) as per American Society of Echocardiography
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45 guidelines.²¹ Per guidelines, diastolic function was defined using three echocardiographic
46
47 parameters: 1) peak early (E) and late (A) diastolic transmitral inflow velocities; 2) early
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49 diastolic (e') annular velocities (the average of septal and lateral annular velocities were used); 3)
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51 left atrial volume indexed (LAVI) to body surface area.²²
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Acculturation Measures

Acculturation was measured by six variables. First, nativity was classified as either born or not outside the US mainland (50 states) and those born in Puerto Rico or other US territories were classified as born outside the US mainland to better reflect their migration and acculturation experiences. Second, foreign-born individuals were asked the number of years lived in the US and categorized as <5, 5-10, 11-20, >20 years. We used Marin's Short Acculturation Scale for Hispanics (SASH),²³ which has a two-factor structure and the two subscales (items related to language use [e.g., language they speak, think] as the SASH language subscale; items related to media preference and social affiliations [e.g., language of media programs watched; ethnicity of close friends] as the SASH social relations subscale) were analyzed separately in our models with higher scores representing higher acculturation. Fifth, language preference was categorized as English vs. Spanish based on language of interview. Finally, generational status (first vs. higher generation) was collected as well as age at the time of migration to the US.

Statistical Analyses

Sampling weights were used to obtain weighted frequencies of descriptive variables and population estimates in the ECHO-SOL target population. We used means \pm standard errors (SEs) for continuous variables and proportions for categorical variables. LVMI, RWT, LVEF, e' annular velocities and LAVI were analyzed as continuous variables. LV diastolic dysfunction (LVDD) was analyzed as a binary variable (present vs. absent).² Acculturation variables were categorical (foreign- vs. US-born; 1st generation vs. 2nd; Spanish language preference vs. English), ordinal (<5, 5-10, 11-20, and >20 years in the US) and continuous measures (age at

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2
3 immigration and SASH subscales). Means were compared across categorical acculturation
4 variables using ANOVA for each measure of cardiac structure (LVMI, RWT, LAVI) and
5 function (LVEF, e' , E/e'). Only significant unadjusted associations for our measures of
6 acculturation were explored in multivariable analysis. Unadjusted and multivariable separate
7 linear and logistic regression analyses were used for our continuous and categorical acculturation
8 variables respectively with each dependent variable measure of cardiac structure and function
9 with sequential modeling for age and sex followed by models including clinical covariates
10 (diabetes, hypertension, and obesity), and behavioral characteristics (physical activity, tobacco
11 use, and alcohol use). For years in the US, we compared >20 years to <5 years as well as an
12 overall comparison across each category of years in the US. We tested effect moderation with
13 income through the use of interaction terms in models followed by stratified analyses by income
14 for statistically significant interactions at the $p < 0.01$ level. All other statistical tests were 2-sided
15 at a significance level of 0.05. All reported values were weighted to account for the HCHS/SOL
16 sampling probability design, stratification, clustering and nonresponse and to make the estimates
17 applicable to the target population from which the HCHS/SOL sample was drawn. All analyses
18 were performed with SAS 9.3 (SAS Institute, Cary, NC)

39 **Patient and public involvement**

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41 No patients were involved in the development of the research question or design of this cohort
42 study.
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47 **Results**

48
49 Fifty-seven percent of the study population were women; almost half had a reported annual
50 income under \$20K; over half were married and most had some type of health insurance (mostly
51 Medicaid and/or Medicare). Hypertension and diabetes were prevalent in half and almost one-
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3 third of the study population respectively. Most of the study population was foreign-born, only
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5 14% preferred English, almost half had been in the US >20 years with a mean age of migration
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7 of 34 years of age, signifying that the majority came to the US as adults (**Table 1**). Mean values
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9 of echocardiographic variables (LAVI, RWT, LVMI, LVEF) are all within normal limits for this
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11 study population. However, mean e' annular velocities and E/e' ratio are borderline abnormal.
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14 Some degree of diastolic dysfunction was seen in over half of the study population but this has
15
16 been previously described.²
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21 **Table S1** shows unadjusted relationships between acculturation measures and echocardiographic
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23 characteristics. LAVI significantly increased with increasing years in the US whereas RWT
24
25 appeared to have a bimodal distribution. A significantly lower annular relaxation velocity and
26
27 higher E/e' ratio was seen among the foreign-born compared to US-born and among those 1st
28
29 generation compared to 2nd generation. Increasing acculturation as measured by increasing
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31 SASH language scale was associated with increasing LAVI. Younger age of migration to US
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33 was associated with higher RWT and increased LAVI.
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40 Adjusted analyses (**Table 2**) demonstrated significantly lower RWT and increased LAVI with
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42 increasing years in the US. A significantly higher E/e' ratio was seen among the foreign-born
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44 participants. Those 1st generation had lower LAVI, lower e' annular velocities and higher E/e'
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46 ratios compared to 2nd generation. Increasing SASH language scale was associated with
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48 increasing LAVI. Lower age of migration to US was associated with increased LAVI. These
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50 associations persisted in sequential models adjusted for clinical factors and behavioral factors
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52 both separately and together. Although greater odds of LVDD was seen in unadjusted
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3 associations with nativity, generational status, SASH language, and age of immigration (**Table**
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5 **3**), these associations did not persist on adjusted analysis.
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10 Significant interactions ($p < 0.01$) were found between our main exposure (acculturation) and
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12 income on the effect of cardiac structure and function. Among those whose annual income is
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14 $> \$20K$, increasing years in the US was associated with increased LVMI, lower e' annular
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16 velocities, and higher E/e' ratio. Generational status was associated with increased LAVI among
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18 those making $> \$20K$ annually. However, being a preferential Spanish-speaker carried a
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20 significantly higher E/e' ratio among those making $< \$20K$. (**Table S2**).
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27 **Discussion**

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29 Hispanics/Latinos in the US represent a relatively young demographic such that the future public
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31 health burden of HF as this population ages is potentially underestimated. Acculturation is
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33 complex, and HCHS-SOL has demonstrated significant heterogeneity in CVD risk factor burden
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35 among Hispanics/Latinos by country of origin and acculturation measures.¹² Despite the limited
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37 understanding of HF risk among Hispanics/Latinos,^{9,24} our analysis of multidimensional
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39 validated acculturation scales provides several important contributions. First, increasing
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41 acculturation, an important phenomenon among immigrant populations, is associated with
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43 abnormal cardiac structure and function in a predominately foreign-born, Spanish-speaking adult
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45 study population despite long residence in the US. Second, different dimensions of acculturation
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47 had varying associations with echocardiographic measures of structure and function. Finally,
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49 income significantly moderated these associations. These findings suggest that exposure to the
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51 social and environmental sources of acculturative stress may promote unhealthy behaviors²⁵ or
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3 act via currently undefined pathways to contribute to HF risk among Hispanics/Latinos. Further
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5 elucidating the acculturative factors influencing HF risk in Hispanics/Latinos is warranted.
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10 Although to our knowledge, there is no existing literature on the association between
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12 acculturation and HF risk, our study found several measures of acculturation (increasing years of
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14 US residence, English preference, and younger age at immigration) were associated with
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16 abnormal cardiac structure and function (increased LAVI, increased LVMI, increased RWT,
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18 lower annular e' relaxation velocity and higher E/e' ratio). Our multivariable models did not
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20 fully account for the deleterious effects of acculturation. An increased E/e' ratio, LAVI, and
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22 LVMI are markers of chronically-elevated filling pressures associated with impaired cardiac
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24 relaxation and HF with preserved ejection fraction.^{26,27} The presence of measures of abnormal
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26 cardiac structure and function have been associated with increased HF hospitalizations,
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28 cardiovascular death and improved CV risk prediction.²⁷⁻²⁹ Importantly, these abnormalities are
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30 additive, with worse outcomes seen in individuals with more than one alteration.²⁷ In order to
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32 identify preclinical CV disease, abnormalities in cardiac structure and function determined by
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34 echocardiography are important intermediary measures, many of which have been associated
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36 with incident CVD, incident clinical HF and increased mortality.⁴⁻⁶ Given the high burden of
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38 acculturation among Hispanics/Latinos, echocardiography might help to identify a particularly
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40 high risk subset of participants.
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49 LVM is associated with CVD, sudden cardiac death, and all-cause mortality.²⁶ Among foreign-
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51 born Hispanics/Latinos, we found increased LVMI with increasing years in the US. Our study is
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53 consistent with prior studies showing a high prevalence of LVM among Hispanics/Latinos
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3 especially among low income Hispanics/Latinos with increasing years of US residence.³⁰⁻³²
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5 Prior studies have demonstrated that adjustment for socioeconomic factors did not fully account
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7 for the presence of increased LVMI among Hispanics/Latinos³³ possibly due to the residual
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9 effect of acculturation. Changes in LVM can occur without overt clinical hypertension in
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11 adrenergic states, such as chronic stress³⁴ with psychosocial factors such as perceived
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13 discrimination and low social support.^{35,36} Acculturative stress, an inability to navigate the
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15 immigrant process and make decisions on retaining one's native culture while adapting to a new
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17 culture, may negatively affect mental and physical health through unhealthy and risky
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19 behaviors²⁵ but also increase rates of anxiety, depression, perceived discrimination and lack of
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21 social support^{14,25,37} which may all lead to cardiac structural and functional abnormalities and
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23 increased HF risk.
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31 The interaction of acculturation with SES on cardiac measures may shed light on the "Hispanic
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33 paradox" which states that Hispanics/Latinos, a disproportionately low SES group, have lower
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35 overall mortality and cardiovascular mortality compared to non-Hispanic Whites.⁹ Low SES is a
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37 composite chronic psychological stressor encompassing multiple factors (e.g., work, housing and
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39 material factors) as well as unmeasured behavioral and situational stress features. Longitudinal
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41 studies have shown an inverse association gradient between SES level and adverse outcomes.³⁵
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43 Studies have shown that low SES and racial/ethnic minority status may combine synergistically
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45 to create high burdens of stress that accumulate over time, leading to deleterious health
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47 consequences.³⁸ However, our study provides additional information, that is those with higher
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49 SES (defined as annual incomes >\$20K) exhibited more deleterious effects of increasing
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51 acculturation on cardiac structural and functional measures. There may be more acculturative
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3 stress for higher-SES immigrants, perhaps through increased contact and interaction with the
4 mainstream culture, which may contribute to our findings. *Familismo* is a culture-specific factor
5 characterized by having strong bonds with nuclear and extended family members resulting in a
6 high level of perceived family support and associated with some indicators of improved
7 health.^{39,40} Studies suggest that increasing acculturation may erode the protective nature of
8 *familismo*.⁴⁰⁻⁴² Further, as Hispanics acculturate into a more individualistic society, dimensions
9 of *familismo* such as familial obligations may increase psychosocial stress rather than alleviate it.
10 For example, a participant may agree that an aging parent should live with relatives, but having a
11 limited income to provide such living arrangements may impart a negative psychosocial stress.
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26 Several limitations of this analysis should be noted. First, this study is cross-sectional and
27 precludes mechanistic causal inference, so our findings warrant replication and longitudinal
28 follow up. Secondly, participants resided in one of four US cities, precluding generalizability to
29 all US Hispanic/Latinos. Our study demonstrates cardiac structure and function abnormalities in
30 a relatively young cohort with a high burden of traditional CVD factors. While this study is one
31 of the largest studies of acculturation with cardiac structure and function in any population, the
32 sample size is modest; thus we are underpowered to perform stratified analyses by national
33 origin in order to characterize the heterogeneity within Hispanic/Latinos. We are specifically
34 referring to acculturation into the US culture which may not be generalizable to acculturation in
35 other settings. Finally, although the ECHO- SOL cohort does not include a non-Hispanic White
36 comparison group, our study focuses on unique intra-ethnic phenomena, as prior research
37 confirms inter-racial/ethnic differences.
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Conclusions

In addition to traditional CV risk factors, acculturation may explain the disproportionate burden of HF risk among Hispanics/Latinos. Our study found significant associations between acculturation measures and deleterious cardiac structural and functional changes among low-SES, foreign-born Hispanic/Latinos with increasing years of residence in the US. Abnormal cardiac structure and function is known to increase the risk of incident clinical HF. Further elucidation of how acculturation impacts risk is warranted in order to possibly risk stratify a high-risk subgroup of Hispanics/Latinos and also to inform the development of culturally-appropriate interventions for Hispanics/Latinos and other immigrants.

1
2
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5
6

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13
14

15
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45

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47

48
49 **Ethics approval:** The Institutional Review Board at the Wake Forest School of Medicine and at
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53 **Data sharing statement:** Data is publically available on request.
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47 Table 1. ECHO-SOL Demographic and Clinical Characteristics
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Demographic Characteristics	Participants (N = 1,818) [†]
Women	1187 (57.4)
Age, mean (SE)	56.4 (0.37)
High School Graduate or Higher	726 (43.3)
Annual Family Income > \$20,000	787 (45.5)
Marital Status	

Single	332 (18.8)
Married/Partner	961 (53.2)
Separated/Divorced/Widow	522 (28.0)
Insured	1042 (60.1)
Short Acculturation Scale for Hispanics (SASH) [mean (SE)]	
Language Use Subscale	1.7 (0.05)
Social Relations Subscale	2.1 (0.03)
Length of US residence [N (%)]	
<5 years	178 (13.6)
5-10 years	247 (15.2)
11-20	385 (22.1)
>20	842 (49.1)
Second generation or higher	185 (9.3)
English language preference	225 (14.0)
Age at migration [mean (SE)]	34.0 (1.0)
US born	163 (7.9)
Clinical Characteristics [N (%)]	
Hypertension	861 (50.0)
Type 2 Diabetes	523 (28.4)
Current Smoker	304 (17.6)
Physical activity level low	1227 (67.3)
BMI \geq 30	822 (44.3)
Current Alcohol Use	770 (43.5)
Echocardiographic Variables [mean (SE)]	
Left Atrial Volume Index	23.0 (0.25)
Relative Wall Thickness	0.40 (0.004)
Left Ventricular Mass Index	82.7 (0.7)
Ejection Fraction	59.8 (0.2)
E prime (e')	8.1 (0.09)
E/e'	10.0 (0.12)
Diastolic Dysfunction [N (%)]	916 (51.9)

†N's presented are unweighted counts of total participants in the ECHO-SOL with each respective characteristic. Percentages are weighted row percentages.

Table 2. Adjusted Analyses of Acculturation Measures with Cardiac Structure and Function.*

	LVMI (g/m ²) β (p)	RWT β (p)	LAVI (mL/m ²) β (p)	LVEF (%) β (p)	e' (cm/s) β (p)	E/e' β (p)
Nativity						
Age, sex	—	—	—	—	-0.349 (0.12)	0.571 (0.02)
Model 1	—	—	—	—	-0.320 (0.10)	0.524 (0.02)
Model 2	—	—	—	—	-0.324 (0.14)	0.532 (0.02)
Model 3	—	—	—	—	-0.303 (0.12)	0.503 (0.02)
Foreign Born (Years in the US)						
Age, sex	—	0.020 (0.06); all (0.03)	-1.74 (0.01); all (0.04)	—	—	—
Model 1	—	0.022 (0.02); all (0.02)	-1.74 (0.01); all (0.05)	—	—	—
Model 2	—	0.018 (0.06); all (0.02)	-1.70 (0.009); all (0.05)	—	—	—
Model 3	—	0.021 (0.02); all (0.007)	-1.71 (0.008); all (0.05)	—	—	—
Generation						
Age, sex	—	—	-0.468 (0.21)	—	-0.529 (0.01)	0.710 (0.002)
Model 1	—	—	-1.797 (0.004)	—	-0.447 (0.01)	0.594 (0.003)
Model 2	—	—	-1.444 (0.03)	—	-0.499 (0.01)	0.671 (0.003)
Model 3	—	—	-1.584 (0.01)	—	-0.425 (0.02)	0.575 (0.006)
SASH Language						
Age, sex	—	—	0.580 (0.01)	—	0.125 (0.10)	—
Model 1	—	—	0.610 (0.008)	—	0.097 (0.11)	—
Model 2	—	—	0.546 (0.01)	—	0.123 (0.15)	—
Model 3	—	—	0.590 (0.007)	—	0.095 (0.16)	—
Age at Immigration						
Age, sex	—	0.0005 (0.15)	-0.040 (0.008)	—	-0.005 (0.27)	—
Model 1	—	0.0005 (0.13)	-0.040 (0.008)	—	-0.006 (0.14)	—
Model 2	—	0.0004 (0.15)	-0.038 (<0.001)	—	-0.005 (0.37)	—
Model 3	—	0.0004 (0.13)	-0.038 (0.01)	—	-0.005 (0.22)	—

*Only acculturation measures that were significant in unadjusted analyses were analyzed in multivariable adjusted models.
 For Years in the US, 1st p value reflects <5 years vs. >20 years comparison. 2nd p value is p value overall for all Years in the US categories
 Model 1: Age, Sex, Diabetes, Hypertension, Obesity | Model 2: Age, Sex, Physical Activity, Tobacco, Alcohol Use | Model 3: Model 1 + Model 2
 LVMI = Left ventricular mass index; RWT = Relative wall thickness; LAVI = Left atrial volume index; LVEF = Left ventricular ejection fraction
 e' = Mitral annular early diastolic velocity; E/e' = Ratio between early mitral inflow velocity and mitral annular early diastolic velocity

Table 3. Unadjusted and Adjusted[‡] Analyses of Acculturation Measures with Diastolic Dysfunction.

		Adjusted Sequential Models			
	Unadjusted	Age, Sex	Model 1	Model 2	Model 3
Nativity					
Foreign born	1.67 (1.08-2.58)	0.98 (0.62-1.55)	0.94 (0.59-1.51)	0.98 (0.62-1.55)	0.95 (0.59-1.53)
US born	Ref				
Years in the US					
<5	0.86 (0.60-1.24)	—	—	—	—
5-10	0.72 (0.49-1.04)				
11-20	0.91 (0.61-1.37)				
>20	Ref				
Generation					
1	1.90 (1.24-2.92)	1.29 (0.77-2.14)	1.18 (0.74-1.91)	1.26(0.77-2.06)	1.18 (0.73-1.89)
2	Ref				
Language Preference					
English	0.67 (0.34-1.32)	—	—	—	—
Spanish	Ref				
SASH Language	0.81 (0.67-0.98)	—	—	—	—
SASH Social	0.88 (0.68-1.15)	—	—	—	—
Age at Immigration	1.02 (1.004-1.03)	1.00 (0.99-1.02)	1.01 (0.995-1.02)	1.01 (0.99-1.02)	1.01 (0.995-1.02)

[‡]Only acculturation measures that were significant in unadjusted analyses were analyzed in adjusted models.

ORs (95% CIs) are presented

Model 1: Age, Sex, Diabetes, Hypertension, Obesity

Model 2: Age, Sex, Physical Activity, Tobacco, Alcohol Use

Model 3: Model 1 + Model 2

Table S1. Unadjusted Acculturation Measures with Echocardiographic Measures of Cardiac Structure and Function.

	LVMI (g/m ²)		RWT		LAVI (mL/m ²)		LVEF (%)		e' (cm/s)		E/e'	
Categorical Measures												
	Mean	p	Mean	p	Mean	p	Mean	p	Mean	p	Mean	p
Nativity												
Foreign Born	82.74	0.92	0.40	0.07	22.93	0.10	59.83	0.54	7.98	<0.001	10.1	<0.001
US Born	82.54		0.38		24.10		59.50		8.99		8.8	
Years in US												
<5 yrs	79.80	0.16	0.41	0.03	21.70	0.03	59.94	0.09	7.71	0.11	10.2	0.25
5-10 yrs	80.43		0.39		22.40		60.04		8.18		9.7	
11-20 yrs	83.60		0.41		22.82		58.94		8.27		9.8	
>20 yrs	83.96		0.39		23.50		60.14		7.86		10.2	
Generation												
First	82.69	0.88	0.40	0.08	22.89	0.02	59.84	0.45	7.97	<0.001	10.1	<0.001
Second or Greater	82.96		0.38		24.41		59.45		9.01		8.8	
Language												
English	81.51	0.59	0.38	0.08	24.00	0.06	60.13	0.48	8.52	0.15	9.7	0.64
Spanish	82.92		0.40		22.87		59.75		7.99		10.0	
Continuous Measures												
	β (se)	p	β (se)	p	β (se)	p	β (se)	p	β (se)	p	β (se)	p
Age at Immigration	-0.0003 (0.0632)	0.99	0.0006 (0.0003)	0.02	-0.030 (0.014)	0.03	-0.003 (0.012)	0.79	-0.023 (0.007)	0.001	0.012 (0.010)	0.23
SASH Subscales												
Language	0.087 (0.735)	0.91	-0.005 (0.003)	0.10	0.539 (0.237)	0.02	0.166 (0.180)	0.36	0.255 (0.098)	0.009	-0.205 (0.109)	0.06
Social Relations	0.086 (1.392)	0.95	-0.009 (0.006)	0.15	0.732 (0.373)	0.05	0.539 (0.295)	0.07	0.266 (0.155)	0.09	-0.156 (0.217)	0.47

LVMI = Left ventricular mass index; RWT = Relative wall thickness; LAVI = Left atrial volume index

LVEF = Left ventricular ejection fraction; e' = Mitral annular early diastolic velocity

E/e' = Ratio between early mitral inflow velocity and mitral annular early diastolic velocity

Table S2. Income Stratified Adjusted Analyses of Acculturation Measures with Cardiac Structure and Function.[‡]

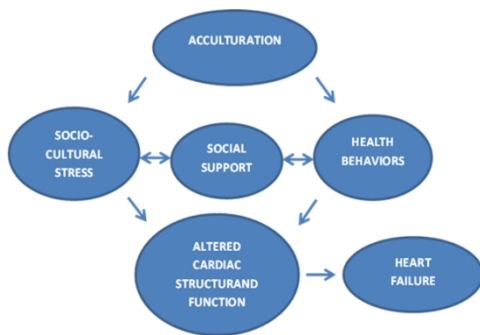
	LVMI (g/m ²)				LAVI (mL/m ²)				e' (cm/s)				E/e'				Diastolic Dysfunction	
	<\$20,000		>\$20,000		<\$20,000		>\$20,000		<\$20,000		>\$20,000		<\$20,000		>\$20,000		<\$20,000	>\$20,000
	Mean	p	Mean	p	Mean	p	Mean	p	Mean	p	Mean	p	Mean	p	Mean	p	ORs (95% CI)	ORs (95% CI)
Nativity																		
Foreign	—	—	—	—	—	—	—	—	7.90	0.0006	8.24	0.048	—	—	—	—	1.67 (0.89-3.14)	1.24 (0.70-2.19)
US born									8.83		8.99							
Years in the US																		
<5	80.02		73.35						7.70		9.03		10.20		9.17			
5-10	81.32	0.15	79.38	0.002	—	—	—	—	7.72	0.27	8.87	0.001	10.36	0.62	8.63	0.003	—	—
11-20	82.22		86.12						8.23		8.56		9.912		9.49			
>20	85.73		82.23						7.87		7.89		10.28		10.16			
Generation																		
1	—	—	—	—	23.04	0.45	22.85	0.02	—	—	—	—	—	—	—	—	1.82 (0.99-3.34)	1.50 (0.83-2.69)
2					23.91		24.67											
Language Preference																		
English	—	—	—	—	—	—	—	—	—	—	—	—	9.42	0.01	10.00	0.63	—	—
Spanish													10.21		9.55			
	β	p	β	p	β	p	β	p	β	p	β	p	β	p	β	p	—	—
SASH Language	—	—	—	—	0.2686	0.32	0.7213	0.04	—	—	—	—	-0.3026	0.003	0.1065	0.60	—	—
SASH Social	—	—	—	—	—	—	—	—	—	—	—	—	-0.5410	0.008	0.4641	0.27	—	—

[‡]Only statistically significant interactions were analyzed in adjusted models; excludes cases where income is missing.
 Multivariable models were adjusted for Age, Sex, Diabetes, Hypertension, Obesity, Physical Activity, Tobacco, and Alcohol Use.
 LVMI = Left ventricular mass index; LAVI = Left atrial volume index
 e' = Mitral annular early diastolic velocity; E/e' = Ratio between early mitral inflow velocity and mitral annular early diastolic velocity

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3 Figure Legend: Proposed Relationship Between Acculturation with Abnormal Cardiac Structure and Function.
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3 **Association of Acculturation with Cardiac Structure and Function among**
4 **Hispanic/Latinos: a cross-sectional analysis of the Echocardiographic Study of Latinos**
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8 **Short Title:** Acculturation and Cardiac Structure and Function
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Abstract

Objective: Hispanics/Latinos, the largest immigrant population in the United States, undergo the process of acculturation and have a large burden of heart failure risk. Few studies have examined the association of acculturation on cardiac structure and function.

Design: cross-sectional

Setting: the Echocardiographic Study of Latinos

Participants: 1,818 Hispanic adult participants with baseline echocardiographic assessment and acculturation measured by the Short Acculturation Scale, nativity, immigration age, length of US residence, generational status and language.

Primary and secondary outcome measures: Echocardiographic assessment of left atrial volume index (LAVI), left ventricular mass index (LVMI), early diastolic transmitral inflow and mitral annular velocities.

Results: The study population was predominantly Spanish-speaking and foreign-born with mean US residence of 22.7 years, mean age of 56.4 years; 50% had hypertension, 28% had diabetes, and 44% had a BMI >30kg/m². Multivariable analyses demonstrated higher LAVI with increasing years of US residence. Foreign-born and first generation participants had higher E/e' but lower LAVI and e' velocities compared to the second generation. Higher acculturation and income >\$20K were associated with higher LVMI, LAVI, and E/e', but lower e' velocities. Preferential Spanish-speakers with an income <\$20K had a higher E/e'.

Conclusions: Acculturation was associated with abnormal cardiac structure and function, with some effect modification seen according to socioeconomic status.

Abstract Word Count: 207

Keywords: Acculturation, Echocardiogram, Hispanics/Latinos, Socioeconomic Status

Strengths and limitations of this study

- A population-based cohort study among predominantly immigrant Hispanic/Latinos in the United States.
- A detailed comprehensive echocardiographic examination was performed to determine cardiac structure and function in every participant.
- Determined whether acculturation, an important sociocultural factor, contributes to the heart failure risk factor burden among an immigrant population.
- We are specifically referring to acculturation into the US culture, which may not be generalizable to acculturation in other settings.

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3 Cardiovascular disease (CVD) and heart failure (HF) risk factor burden is high among
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5 Hispanic/Latinos in the United States (US)^{1,2} compared to non-Hispanic whites leading to
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7 abnormalities of cardiac structure and function³ which have been associated with incident
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9 clinical HF,⁴ incident CVD and increased mortality.⁵⁻⁸

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14 With respect to HF, Hispanics/Latinos have a higher incidence compared to non-Hispanic whites
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16 and Hispanics/Latinos who present with HF are younger with more co-morbidities and a lower
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18 left ventricular (LV) ejection fraction (EF) compared to non-Hispanic whites.^{2,9-11} Beyond
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20 traditional HF risk factors (hypertension, diabetes and obesity), sociocultural factors such as
21
22 acculturation, may contribute to HF risk among Hispanic/Latinos (**Figure 1/Conceptual**
23
24 **Model**)² but the impact of acculturation on cardiac structure and function has not been examined.
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26 The fact that Hispanics/Latinos are the largest immigrant population in the US accentuates the
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28 public health impact of studying the impact of acculturation on cardiac parameters.
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36 Acculturation is a multidimensional process whereby immigrants adapt to the beliefs and
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38 practices of a host culture.¹² This can pose a chronic daily stressor for many immigrants that can
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40 affect physical health outcomes. Acculturation has been associated with increased psychosocial
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42 stress, deleterious CV health behaviors and a higher CV risk factor burden.¹³⁻¹⁶ In our
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44 mechanistic framework, the acculturative process leads to increase stressors and worse health
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46 behaviors which separately or jointly alter cardiac structure and function to increase HF risk.
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48 Few studies^{17,18} have examined acculturation in relation to HF risk specifically focusing on
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50 cardiac structure and function as key intermediary outcomes.
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3 We primarily sought to test whether acculturation, an important sociocultural variable with
4 biopsychosocial implications, is associated with cardiac structure and function among
5 Hispanics/Latinos. Studies of acculturation and CVD often overlook socioeconomic status (SES)
6 as an effect modifier. Because SES is associated with cardiac parameters¹⁹ and modifies the
7 association between acculturation and other health-related variables,²⁰ secondarily, we sought to
8 test whether our primary associations are moderated by SES.
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19 **Methods**

20 **Cohort Description**

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22 The Hispanic Community Health Study/Study of Latinos (HCHS/SOL) is a population-based
23 study of 16,415 Hispanic/Latinos from randomly selected households at four US field centers
24 (Bronx, NY; Chicago, IL; Miami, FL; and San Diego, CA).²¹ Probability sampling was used to
25 ensure broad representation of the target population and to minimize the sources of bias that may
26 otherwise enter into the cohort selection and recruitment process. Participants were between 18
27 and 74 years of age, and self-identified as Cuban, Central American, Dominican, Mexican,
28 Puerto Rican, or South American Hispanic/Latino heritage. The ECHO-SOL ancillary study was
29 designed to provide echocardiographic parameters characterizing cardiac structure and function
30 in a representative HCHS/SOL baseline subsample of 1,818 participants ≥ 45 years old.^{3,22}
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32 Institutional Review Board approval was obtained at each study site and all ECHO-SOL
33 participants gave informed consent prior to participating in the study.
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51 **Patient and public involvement**

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3 No patients were involved in the development of the research question, design, recruitment or
4 implementation of this research cohort study. Results were disseminated to study participants in
5 the form of a Data Book and periodic newsletters. See www.saludsol.net.
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10 11 12 **In-Person Examination** 13

14 The examination protocol for the parent HCHS/SOL has been previously published.¹³ Obesity
15 was defined as a body mass index (BMI) ≥ 30.0 kg/m². Seated resting blood pressures were
16 measured in triplicate and the average of the 2nd and 3rd readings was used for analysis. Type 2
17 diabetes was defined based on American Diabetes Association definition using one or more of
18 the following criteria: 1) fasting serum glucose ≥ 126 mg/dl, 2) oral glucose tolerance test ≥ 200
19 mg/dl, 3) self-reported diabetes, 4) HbA1C $\geq 6.5\%$, or 5) taking anti-diabetic medication or
20 insulin. Renal function was measured by estimated glomerular filtration rate (eGFR). Physical
21 activity levels, categorized as low or medium/high, were assessed using the Global Physical
22 Activity Questionnaire.²³ Self-report questionnaires assessed smoking status (no/ever/current),
23 alcohol consumption (current/no), and insurance coverage (yes/no) and type
24 (Private/Medicare/Medicaid). Socioeconomic status was defined as highest degree or level of
25 school completed and household income level – dichotomized as $< \$20,000$ and $> \$20,000$, given
26 the low number of participants with incomes $> \$40,000$. Our secondary analysis focused on
27 current income while living in the US as more relevantly influencing a participant's acculturative
28 process, acting as a proxy for the ability to integrate and be exposed to mainstream US cultural
29 contexts. Marital status categorized as (single/married/partnered/separated/divorced/widowed).
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54 **Echocardiographic Measurements** 55 56 57

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3 Trained sonographers performed transthoracic echocardiography examinations, including 2D
4 imaging, and spectral, color and tissue Doppler.²² Echocardiographic measures of left and right
5 heart structure and function included:
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10 1) LV mass index (LVMI) was determined according to guidelines,²⁴ by subtracting the LV
11 endocardial cavity volume from the LV epicardial volume and multiplying the resultant
12 myocardial volume by the myocardial density and indexing to body surface area.
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- 15 2) LV systolic function and volumes. LVEF was derived from Volumetric Assessments using
16 the method of discs from apical 4- and 2-chamber long-axis views to measure end-diastolic
17 volume (EDV) and end-systolic volume (ESV). LVEF was calculated: $(EDV - ESV)/EDV$.
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19
- 20 3) LV diastolic function was defined per guidelines,²⁵ using three echocardiographic
21 parameters: 1) peak early (E) and late (A) diastolic transmitral inflow velocities; 2) early
22 diastolic (e') annular velocities (the average of septal and lateral annular velocities were
23 used); 3) left atrial volume indexed (LAVI) to body surface area.
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25
- 26 4) Relative Wall Thickness (RWT) defined as: $[(\text{posterior wall thickness} \times 2) / \text{LV diastolic}$
27 diameter] predicates LV geometry. Higher RWT values are associated with a smaller LV
28 cavity size and lower RWT values are associated with higher LV cavity sizes.
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42 **Acculturation Measures**

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44 Acculturation was characterized according to several measured variables. First, nativity was
45 classified as either born in or outside the US mainland (50 states). Those born in Puerto Rico
46 (PR) or other US territories were classified as born outside of the US mainland to reflect their
47 migration and acculturation experiences. Second, foreign-born individuals were asked the
48 number of years lived in the US and categorized as <5, 5-10, 11-20, >20 years. We used the
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3 Short Acculturation Scale for Hispanics (SASH),²⁶ which has two subscales based on five-point
4 Likert type questions: 1. the SASH language subscale (items related to language use [e.g.,
5 language they speak, think]); and 2. the SASH social relations subscale (items related to media
6 preference and social affiliations [e.g., language of media programs watched; ethnicity of close
7 friends]). The SASH has yielded reliabilities (α) of 0.92 (overall), 0.90 (language use), 0.86
8 (media preference), and 0.78 (ethnic and social relations). These subscales were analyzed
9 separately with higher scores representing higher degrees of acculturation. Fifth, language
10 preference was further characterized as English vs. Spanish based on language of interview.
11 Finally, data on generational status (first- and second-generation Hispanics are US-born and
12 distinct from their foreign-born immigrant parents) was collected as well as age at the time of
13 migration to the US.
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31 **Statistical Analyses**

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33 Sampling weights were used to obtain weighted frequencies of descriptive variables and
34 population estimates in the ECHO-SOL target population. We used means \pm standard errors
35 (SEs) for continuous variables and proportions for categorical variables. LVMI, RWT, LVEF, e'
36 annular velocities and LAVI were analyzed as continuous variables. LV diastolic dysfunction
37 (LVDD) was analyzed as a binary variable (present vs. absent).³ Acculturation variables were
38 categorical (foreign- vs. US-born; 1st generation vs. 2nd; Spanish language preference vs.
39 English), ordinal (<5, 5-10, 11-20, and >20 years in the US) and continuous measures (age at
40 immigration and SASH subscales). Weighted means and linear regression analysis was utilized
41 for continuous variables whereas weighted frequencies and Rao-Scott Chi-Square was utilized
42 for the categorical/ordinal variables. Means were compared across categorical acculturation
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3 variables using ANOVA for each measure of cardiac structure (LVMI, RWT, LAVI) and
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5 function (LVEF, e' , E/e'). Only significant unadjusted associations were further explored in
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7 multivariable analysis. Unadjusted and multivariable linear and logistic regression analyses were
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9 determined by our continuous and categorical dependent variable measures of cardiac structure
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11 and function, respectively utilizing sequential modeling for age and sex followed by models
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13 including clinical covariates (diabetes, hypertension, and obesity), and behavioral characteristics
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15 (physical activity, tobacco use, and alcohol use). For years in the US, we compared >20 years to
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17 <5 years as well as an overall comparison across each category of years in the US. We performed
18
19 a couple of exploratory analyses (data not shown): 1. comparing acculturative characteristics of
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21 individuals born in the island of PR vs. other foreign-born Hispanics; 2. comparing acculturation
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23 and health care utilization using HCHS/SOL questions regarding primarily regarding difficulty
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25 obtaining health care in the past year and number of physician visits in the past year. We tested
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27 effect moderation with income through the use of interaction terms in models followed by
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29 stratified analyses by income for statistically significant interactions at the $p < 0.01$ level. All
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31 other statistical tests were 2-sided at a significance level of 0.05. All reported values were
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33 weighted to account for HCHS/SOL sampling probability design, stratification, clustering and
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35 nonresponse and to make estimates applicable to the HCHS/SOL target population. All analyses
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37 were performed utilizing SAS 9.3 (SAS Institute, Cary, NC) survey statistics, which produce
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39 standard errors (SEs) not standard deviations.
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49 **Results**

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51 Fifty-seven percent of the study population were women; almost half (46%) had a reported
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53 annual income under \$20K; over half were married and most had some type of health insurance
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3 (mostly Medicaid and/or Medicare). Hypertension and diabetes were prevalent in half and almost
4 one-third of the study population respectively. Most of the study population was foreign-born,
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6 only 14% preferred English, almost half (49%) had been in the US >20 years with a mean age of
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8 migration of 34 years of age, signifying that the majority came to the US as adults (**Table 1**).
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10 Mean values of echocardiographic variables (LAVI, RWT, LVMI, LVEF) were all within
11
12 normal limits for this study population. However, mean e' annular velocities and E/e' ratio were
13
14 borderline abnormal. Some degree of diastolic dysfunction was seen in over half (52%) of the
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16 study population but this has been previously described.³
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24 **Table S1** shows unadjusted relationships between acculturation measures and echocardiographic
25 characteristics. LAVI was positively associated with increasing years in the US whereas RWT
26 appeared to have a U-shaped association. A statistically significantly lower annular relaxation
27 velocity and higher E/e' ratio was seen among the foreign-born compared to US-born and among
28 those 1st generation compared to 2nd generation. Higher acculturation as measured by increasing
29 SASH language scale was associated with increasing LAVI. Younger age of migration to US
30 was associated with higher RWT and increased LAVI.
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42 Adjusted analyses (**Table 2**) demonstrated statistically significantly greater RWT and higher
43 LAVI with more years in the US. A statistically significantly higher E/e' ratio was seen among
44 the foreign-born participants. Those 1st generation had lower LAVI, lower e' annular velocities
45 and higher E/e' ratios compared to 2nd generation. Increasing SASH language scale was
46 associated with higher LAVI whereas younger age of migration to US was associated with
47 higher LAVI and RWT. These associations persisted in sequential models adjusted for clinical
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3 factors and behavioral factors both separately and together. Although greater odds of LVDD was
4 seen in unadjusted associations with nativity, generational status, SASH language, and age of
5 immigration (**Table 3**), these associations did not persist on adjusted analysis.
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12 Significant interactions ($p < 0.01$) were found between our main exposure (acculturation) and
13 income on the effect of cardiac structure and function. Among those whose annual income is
14 $> \$20K$, a greater number of years in the US was associated with higher LVMI, lower e' annular
15 velocities, and a higher E/e' ratio compared to those making $< \$20K$ annually. Generational status
16 was associated with increased LAVI only among those making $> \$20K$ annually. However, being
17 a preferential Spanish-speaker carried a statistically significant higher E/e' ratio only among
18 those making $< \$20K$ annually. (**Table S2**).
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31 Of foreign-born Hispanics, 24% were born in the US Commonwealth of PR, none in the US
32 Virgin Islands. Spanish language preference was less among Hispanics born in PR compared to
33 other foreign-born Hispanics. PR-born Hispanics scored higher on the SASH language scale and
34 social interaction scale indicating higher acculturation levels compared to other foreign-born
35 Hispanics. However, the level of Spanish language preference and SASH scores was still lower
36 among PR-born Hispanics compared to US born Hispanics. With regard to acculturation and
37 health care utilization, being foreign-born, less years in the US and not having health insurance
38 were all significantly associated with difficulty obtaining health care in the past year. Foreign-
39 born individuals had less physician visits over the past year compared to US born. The relation
40 between years in the US and physician visits was complex, non-linear and mirrored an opposite
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3 pattern with income. **(Figure 2)** Having health insurance coverage was significantly associated
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5 with more physician visits over the past year.
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8 9 **Discussion**

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11 Hispanics/Latinos in the US represent a relatively young demographic such that the future public
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13 health burden of HF as this population ages is potentially underestimated.²⁷ The Hispanic
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15 population >65 years of age is expected to grow 328% between 2000 and 2030, making
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17 Hispanics the fastest growing aging population in the US.²⁸ As the Hispanic population ages, and
18
19 HF risk factors and cardiac abnormalities progress, it is likely that an epidemic of HF in
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21 Hispanics will emerge.
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27 Acculturation is complex and has four domains: (1) integration - maintaining attitudes and
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29 behaviors of the original parent culture while adopting the host culture; (2) assimilation -
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31 rejecting the ways of the parent culture and entirely adopting the host culture; (3) separation -
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33 rejecting the host culture and keeping the practices and behaviors of the parent culture; and (4)
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35 marginalization - not identifying with the original culture or the host culture. Prior studies show
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37 strong negative effects of greater acculturation on worsening CV risk factors but positive effects
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39 on use of preventive health services.²⁹⁻³¹ HCHS/SOL has demonstrated significant heterogeneity
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41 in CVD risk factor burden among Hispanics/Latinos by country of origin and acculturation
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43 measures.¹³ Despite the current understanding of HF risk among Hispanics/Latinos,^{2,9} our
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45 analysis of validated acculturation scales provides several important contributions. First,
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47 Spanish language preference and SASH scores were higher among Hispanics born in PR
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49 compared to other foreign-born Hispanics but this proportion was still significantly less than US-
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51 born Hispanics. Suggesting that for many, living in the island of PR still allows for maintenance
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3 of a culture that is distinct from the US culture. Second, higher levels of acculturation, an
4 important phenomenon among immigrant populations, was associated with abnormal cardiac
5 structure and function in our predominately foreign-born, Spanish-speaking adult population
6 despite long residence in the US. Third, different measures of acculturation (each capturing
7 different aspects of the acculturative process) had varying associations with echocardiographic
8 measures of structure and function. Finally, income significantly moderated these associations.
9
10 Our findings support the premise that exposure to the social and environmental stress of
11 acculturation may promote unhealthy behaviors³² and/or act via currently undefined pathways to
12 contribute to HF risk among Hispanics/Latinos. **(Figure 2)** Further elucidating the acculturative
13 factors influencing HF risk in Hispanics/Latinos is warranted.
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28 Although to our knowledge, there is no existing literature on the association between
29 acculturation and HF risk, our study found several measures of acculturation (increasing years of
30 US residence, English preference, and younger age at immigration) were associated with
31 abnormal cardiac structure and function (increased LAVI, increased LVMI, increased RWT,
32 lower annular e' relaxation velocity and higher E/e' ratio). Although the magnitudes of our
33 observed associations are modest, limiting the short-term clinical relevance of these findings, the
34 long-term public health importance is likely high, given the potential for progression of cardiac
35 damage with the accumulation of acculturative stress during the life course. This is particularly
36 salient given the fact that abnormal cardiac structure and function is an independent risk factor
37 for the future development of clinical HF. An increased E/e' ratio, LAVI, and LVMI are markers
38 of chronically-elevated filling pressures associated with impaired cardiac relaxation and HF with
39 preserved ejection fraction.^{33,34} The presence of abnormal cardiac structure and function has been
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3 associated with increased HF hospitalizations, cardiovascular death and improved CV risk
4 prediction.³⁴⁻³⁶ Importantly, these cardiac abnormalities are additive, with worse outcomes seen
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6 in individuals with more than one alteration.³⁴ In order to identify preclinical CV disease,
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8 abnormalities in cardiac structure and function determined by echocardiography are important
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10 intermediary measures, many of which have been associated with incident CVD, incident clinical
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12 HF and increased mortality.⁵⁻⁷ Given the size of the US Hispanic/Latino population and high
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14 burden of acculturation (82% were foreign-born), echocardiography might help to identify a
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16 particularly high risk subset of participants.
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24 LVM is associated with CVD, sudden cardiac death, and all-cause mortality.³³ Among foreign-
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26 born Hispanics/Latinos, we found increased LVMI with increasing years in the US. Our study is
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28 consistent with prior studies showing a high prevalence of LVM among Hispanics/Latinos
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30 especially among low income Hispanics/Latinos with increasing years of US residence.^{18,37,38}
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32 Prior studies have demonstrated that adjustment for socioeconomic factors did not fully account
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34 for the presence of increased LVMI among Hispanics/Latinos³⁹ possibly due to the residual
35
36 effect of acculturation. Changes in LVM can occur without overt clinical hypertension in
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38 adrenergic states, such as chronic stress⁴⁰ with psychosocial factors such as perceived
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40 discrimination and low social support.^{41,42} Acculturative stress is the psychological impact or
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42 stress reaction of navigating the acculturation process and making decisions on retaining one's
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44 native culture while adapting to a new cultural context. Acculturation may act as a chronic
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46 stressor, negatively affecting mental and physical health through unhealthy behaviors,^{30,32}
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48 increased anxiety, depression, perceived discrimination and lack of social support^{15,32,43} which
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3 may impact adrenergic biomarkers leadings to cardiac structural and functional abnormalities
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5 and increased HF risk. This is another area of research to further explore in future studies.
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10 The interaction of acculturation with SES on cardiac measures may shed light on the “Hispanic
11 paradox” which states that Hispanics/Latinos, a disproportionately low SES group, have lower
12 overall mortality and cardiovascular mortality compared to non-Hispanic Whites.² Low SES is a
13 composite chronic stressor encompassing multiple factors (e.g., work, housing and financial
14 strain). Longitudinal studies have shown an inverse association between SES level and adverse
15 outcomes.^{41,44} We hypothesized that less acculturation (more retention of host culture) may be
16 protective of the adverse health consequences of low SES. In our study, those with higher SES
17 (defined as annual incomes >\$20K) exhibited more deleterious effects of increasing
18 acculturation on cardiac structural and functional measures. A prior study found the relationship
19 between acculturation and health care utilization to be complex and moderated by SES.⁴⁵ Our
20 exploratory analysis found that being foreign-born and having a higher income may make one
21 less likely to utilize health care. A more extensive analysis on the complex nature of
22 acculturation and health care utilization is beyond the scope of our paper but this area deserves
23 further consideration in future studies. There may be more acculturative stress for higher-SES
24 immigrants, perhaps through increased contact and interaction with the mainstream culture,⁴⁶
25 which may contribute to our findings. *Familismo* is a culture-specific factor characterized by
26 having strong bonds with nuclear and extended family resulting in a high level of perceived
27 family support and is associated with indicators of improved health.^{47,48} Studies suggest that with
28 increasing acculturation, *familismo* is eroded and dimensions of *familismo* begin to increase
29 psychosocial stress rather than alleviate it.⁴⁸⁻⁵⁰
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6 Several limitations should be noted. Our study is cross-sectional and precludes the ability to
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8 assess the temporal sequence of the relationships and causal inference. However, our findings
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10 warrant replication and longitudinal follow up. Participants resided in one of four US cities,
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12 precluding generalizability to all Hispanic/Latinos in the US. While this study is one of the
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14 largest studies of acculturation with cardiac structure and function in any population, the sample
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16 size is relatively modest; thus, we were underpowered to perform stratified analyses by national
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18 origin in order to characterize the heterogeneity within Hispanic/Latinos. We are specifically
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20 referring to acculturation into the US culture, which may not be generalizable to acculturation in
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22 other settings. Finally, our study focuses on acculturation as a unique intra-ethnic phenomenon.
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24 By including several measures (nativity, years of US residence/age at migration, SASH
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26 subscales, language preference and generational status) our goal was to be comprehensive and to
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28 capture several aspects of acculturation. We believe acculturation cannot be captured by just one
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30 measure, as has been done in much of the prior literature; however, we agree that even our
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32 multivariable approach may not fully capture the complexities of all aspects and dimensions of
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34 the acculturative process.
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42 **Conclusions**

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44 In addition to traditional CV risk factors, acculturation may explain the disproportionate burden
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46 of HF risk among Hispanics/Latinos. Our study found significant associations between several
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48 acculturation measures with deleterious cardiac structural and functional parameters among a
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50 predominantly low-SES, foreign-born Hispanic/Latino population with increasing years of
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52 residence in the US. The acculturation experience is not unique to Hispanics/Latinos. Our study
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3 may help generate further research in other immigrant populations. Further elucidation of how
4 acculturation impacts HF risk is warranted in order to possibly risk stratify a high-risk subgroup
5 of Hispanics/Latinos and to inform the development of culturally appropriate interventions to
6 amplify protective factors and to make the acculturative process less deleterious for
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Hispanics/Latinos and other immigrants.

For peer review only

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2
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5
6

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8 CJR, MAA, RK, LCG; **Analysis and interpretation of the data:** CJR, LL, KS; **Drafting of the**
9 **article:** CJR, LL, FR; **Critical revision of the article for important intellectual content:** CJR,
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12
13

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15
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17

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45

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51

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Table 1. ECHO-SOL Demographic and Clinical Characteristics (N = 1,818)[†]

Demographic Characteristics	[N (%)]
Women	1187 (57.4)
Age, [mean (SE)]	56.4 (0.37)
High School Graduate or Higher	726 (43.3)
Annual Family Income > \$20,000	787 (45.5)
Marital Status	
Single	332 (18.8)
Married/Partner	961 (53.2)
Separated/Divorced/Widow	522 (28.0)
Health Insurance	1042 (60.1)
Short Acculturation Scale for Hispanics (SASH)	[mean (SE)]
Language Use Subscale	1.7 (0.05)
Social Relations Subscale	2.1 (0.03)
Length of US residence	[N (%)]
<5 years	178 (13.6)
5-10 years	247 (15.2)
11-20	385 (22.1)
>20	842 (49.1)
Second generation or higher	185 (9.3)
English language preference	225 (14.0)
Age at migration [mean (SE)]	34.0 (1.0)
US born	163 (7.9)
Clinical Characteristics	[N (%)]
Hypertension	861 (50.0)
Type 2 Diabetes	523 (28.4)
Current Smoker	304 (17.6)
Physical activity level low	1227 (67.3)
BMI ≥30	822 (44.3)
Current Alcohol Use	770 (43.5)
Echocardiographic Variables	[mean (SE)]
Left Atrial Volume Index (≤33 mL/m ²)	23.0 (0.25)
Relative Wall Thickness (0.22-0.42)	0.40 (0.004)
Left Ventricular Mass Index (45-105 g/m ²)	82.7 (0.7)
Ejection Fraction (≥55 %)	59.8 (0.2)
E prime (e') (8-16 cm/s)	8.1 (0.09)
E/e' (≤12)	10.0 (0.12)
Diastolic Dysfunction [N (%)]	916 (51.9)

[†]N's presented are unweighted counts of total participants in the ECHO-SOL with each respective characteristic.

Percentages are weighted row percentages.

Normal values are provided for cardiac structure and function variables.

Table 2. Adjusted Analyses of Acculturation Measures with Cardiac Structure and Function.*

	LVMI (g/m²) β (p)	RWT β (p)	LAVI (mL/m²) β (p)	LVEF (%) β (p)	e' (cm/s) β (p)	E/e' β (p)
Nativity						
Age, sex	—	—	—	—	-0.349 (0.12)	0.571 (0.02)
Model 1	—	—	—	—	-0.320 (0.10)	0.524 (0.02)
Model 2	—	—	—	—	-0.324 (0.14)	0.532 (0.02)
Model 3	—	—	—	—	-0.303 (0.12)	0.503 (0.02)
Foreign Born (Years in the US)						
Age, sex	—	0.020 (0.06); all (0.03)	1.57 (0.02); all (<0.05)	—	—	—
Model 1	—	0.022 (0.02); all (0.02)	1.63 (0.02); all (<0.05)	—	—	—
Model 2	—	0.018 (0.06); all (0.02)	1.55 (0.02); all (0.05)	—	—	—
Model 3	—	0.021 (0.02); all (0.007)	1.71 (0.01); all (0.04)	—	—	—
Generation						
Age, sex	—	—	-0.468 (0.21)	—	-0.529 (0.01)	0.710 (0.002)
Model 1	—	—	-1.797 (0.004)	—	-0.447 (0.01)	0.594 (0.003)
Model 2	—	—	-1.444 (0.03)	—	-0.499 (0.01)	0.671 (0.003)
Model 3	—	—	-1.584 (0.01)	—	-0.425 (0.02)	0.575 (0.006)
SASH Language						
Age, sex	—	—	0.580 (0.01)	—	0.125 (0.10)	—
Model 1	—	—	0.610 (0.008)	—	0.097 (0.11)	—
Model 2	—	—	0.546 (0.01)	—	0.123 (0.15)	—
Model 3	—	—	0.590 (0.007)	—	0.095 (0.16)	—
Age at Immigration						
Age, sex	—	0.0005 (0.15)	-0.040 (0.008)	—	-0.005 (0.27)	—
Model 1	—	0.0005 (0.13)	-0.040 (0.008)	—	-0.006 (0.14)	—
Model 2	—	0.0004 (0.15)	-0.038 (<0.001)	—	-0.005 (0.37)	—
Model 3	—	0.0004 (0.13)	-0.038 (0.01)	—	-0.005 (0.22)	—

*Only acculturation measures that were significant in unadjusted analyses were analyzed in multivariable adjusted models.
 For Years in the US, the 1st p-value reflects <5 years vs. >20 years comparison; whereas the 2nd p-value is for overall comparison across all the Years in the US categories (<5; 5-10; 11-20; >20)
 Model 1: Age, Sex, Diabetes, Hypertension, Obesity | Model 2: Age, Sex, Physical Activity, Tobacco, Alcohol Use | Model 3: Model 1 + Model 2
 LVMI = Left ventricular mass index; RWT = Relative wall thickness; LAVI = Left atrial volume index; LVEF = Left ventricular ejection fraction
 e' = Mitral annular early diastolic velocity; E/e' = Ratio between early mitral inflow velocity and mitral annular early diastolic velocity

Table 3. Unadjusted and Adjusted[‡] Analyses of Acculturation Measures with Diastolic Dysfunction.

		Adjusted Sequential Models			
	Unadjusted	Age, Sex	Model 1	Model 2	Model 3
Nativity					
Foreign born	1.67 (1.08-2.58)	0.98 (0.62-1.55)	0.94 (0.59-1.51)	0.98 (0.62-1.55)	0.95 (0.59-1.53)
US born	Ref				
Years in the US					
<5	0.86 (0.60-1.24)	—	—	—	—
5-10	0.72 (0.49-1.04)				
11-20	0.91 (0.61-1.37)				
>20	Ref				
Generation					
1	1.90 (1.24-2.92)	1.29 (0.77-2.14)	1.18 (0.74-1.91)	1.26(0.77-2.06)	1.18 (0.73-1.89)
2	Ref				
Language Preference					
English	0.67 (0.34-1.32)	—	—	—	—
Spanish	Ref				
SASH Language	0.81 (0.67-0.98)	—	—	—	—
SASH Social	0.88 (0.68-1.15)	—	—	—	—
Age at Immigration	1.02 (1.004-1.03)	1.00 (0.99-1.02)	1.01 (0.995-1.02)	1.01 (0.99-1.02)	1.01 (0.995-1.02)

[‡]Only acculturation measures that were significant in unadjusted analyses were analyzed in adjusted models.

ORs (95% CIs) are presented

Model 1: Age, Sex, Diabetes, Hypertension, Obesity

Model 2: Age, Sex, Physical Activity, Tobacco, Alcohol Use

Model 3: Model 1 + Model 2

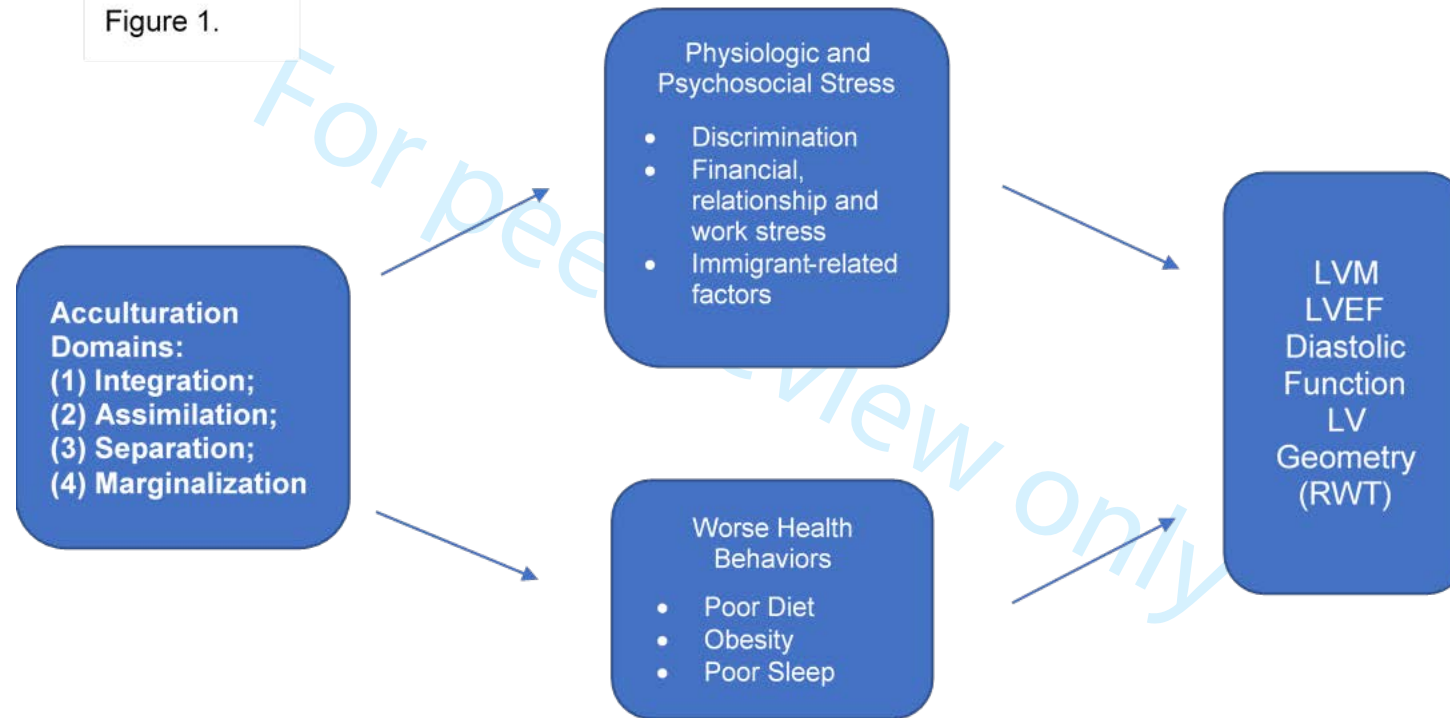
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6 Figure 1. Proposed Relationships Between Acculturation with Cardiac Structure and Function.
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8 Figure 2. Relation of Years Residing in the US or Income Level with Number of Physician Visits
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Figure 1.



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Figure 2.



Table S1. Unadjusted Acculturation Measures with Echocardiographic Measures of Cardiac Structure and Function.

	LVMI (g/m ²)		RWT		LAVI (mL/m ²)		LVEF (%)		e' (cm/s)		E/e'	
Categorical Measures												
	Mean	p	Mean	p	Mean	p	Mean	p	Mean	p	Mean	p
Nativity												
Foreign Born	82.74	0.92	0.40	0.07	22.93	0.10	59.83	0.54	7.98	<0.001	10.1	<0.001
US Born	82.54		0.38		24.10		59.50		8.99		8.8	
Years in US												
<5 years	79.80	0.16	0.41	0.03	21.70	0.03	59.94	0.09	7.71	0.11	10.2	0.25
5-10 years	80.43		0.39		22.40		60.04		8.18		9.7	
11-20 years	83.60		0.41		22.82		58.94		8.27		9.8	
>20 years	83.96		0.39		23.50		60.14		7.86		10.2	
Generation												
First	82.69	0.88	0.40	0.08	22.89	0.02	59.84	0.45	7.97	<0.001	10.1	<0.001
Second or Greater	82.96		0.38		24.41		59.45		9.01		8.8	
Language												
English	81.51	0.59	0.38	0.08	24.00	0.06	60.13	0.48	8.52	0.15	9.7	0.64
Spanish	82.92		0.40		22.87		59.75		7.99		10.0	
Continuous Measures												
	β (se)	p	β (se)	p	β (se)	p	β (se)	p	β (se)	p	β (se)	p
Age at Immigration	-0.0003 (0.0632)	0.99	0.0006 (0.0003)	0.02	-0.030 (0.014)	0.03	-0.003 (0.012)	0.79	-0.023 (0.007)	0.001	0.012 (0.010)	0.23
SASH Subscales												
Language	0.087 (0.735)	0.91	-0.005 (0.003)	0.10	0.539 (0.237)	0.02	0.166 (0.180)	0.36	0.255 (0.098)	0.009	-0.205 (0.109)	0.06
Social Relations	0.086 (1.392)	0.95	-0.009 (0.006)	0.15	0.732 (0.373)	0.05	0.539 (0.295)	0.07	0.266 (0.155)	0.09	-0.156 (0.217)	0.47

LVMI = Left ventricular mass index; RWT = Relative wall thickness; LAVI = Left atrial volume index

LVEF = Left ventricular ejection fraction; e' = Mitral annular early diastolic velocity

E/e' = Ratio between early mitral inflow velocity and mitral annular early diastolic velocity

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Table S2. Income Stratified Adjusted Analyses of Acculturation Measures with Cardiac Structure and Function.[‡]

	LVMI (g/m ²)				LAVI (mL/m ²)				e' (cm/s)				E/e'				Diastolic Dysfunction	
	<\$20,000		>\$20,000		<\$20,000		>\$20,000		<\$20,000		>\$20,000		<\$20,000		>\$20,000		<\$20,000	>\$20,000
	Mean	p	Mean	p	Mean	p	Mean	p	Mean	p	Mean	p	Mean	p	Mean	p	ORs (95% CI)	ORs (95% CI)
Nativity																		
Foreign	—	—	—	—	—	—	—	—	7.90	0.0006	8.24	0.048	—	—	—	—	1.67 (0.89-	1.24 (0.70-
US born									8.83		8.99						3.14)	2.19)
Years in the US																		
<5	80.02		73.35						7.70		9.03		10.20		9.17			
5-10	81.32	0.15	79.38	0.002	—	—	—	—	7.72	0.27	8.87	0.001	10.36	0.62	8.63	0.003	—	—
11-20	82.22		86.12						8.23		8.56		9.912		9.49			
>20	85.73		82.23						7.87		7.89		10.28		10.16			
Generation																		
1	—	—	—	—	23.04	0.45	22.85	0.02	—	—	—	—	—	—	—	—	1.82 (0.99-	1.50 (0.83-
2					23.91		24.67										3.34)	2.69)
Language Preference																		
English	—	—	—	—	—	—	—	—	—	—	—	—	9.42	0.01	10.00	0.63	—	—
Spanish													10.21		9.55			
	β	p	β	p	β	p	β	p	β	p	β	p	β	p	β	p	—	—
SASH Language	—	—	—	—	0.2686	0.32	0.7213	0.04	—	—	—	—	-0.3026	0.003	0.1065	0.60	—	—
SASH Social	—	—	—	—	—	—	—	—	—	—	—	—	-0.5410	0.008	0.4641	0.27	—	—

[‡]Only statistically significant interactions were analyzed in adjusted models; excludes cases where income is missing.
 Multivariable models were adjusted for Age, Sex, Diabetes, Hypertension, Obesity, Physical Activity, Tobacco, and Alcohol Use.
 LVMI = Left ventricular mass index; LAVI = Left atrial volume index
 e' = Mitral annular early diastolic velocity; E/e' = Ratio between early mitral inflow velocity and mitral annular early diastolic velocity

STROBE Statement—Checklist of items that should be included in reports of *Observational studies*
in epidemiology

	Item No	Recommendation	Page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1&
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	3&4
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any pre-specified hypotheses	4&5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	5
		(b) For matched studies, give matching criteria and number of exposed and unexposed	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6&7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6&7
Bias	9	Describe any efforts to address potential sources of bias	8
Study size	10	Explain how the study size was arrived at	5&9
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6&7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	8&9
		(b) Describe any methods used to examine subgroups and interactions	
		(c) Explain how missing data were addressed	
		(d) If applicable, explain how loss to follow-up was addressed	
		(e) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	Report numbers of outcome events or summary measures over time	10&11
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10&11
		(b) Report category boundaries when continuous variables were categorized	
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a	

1		meaningful time period	
2	Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
3			11
4			
5	Discussion		
6	Key results	18	Summarise key results with reference to study objectives
7			12&13
8	Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
9			16
10	Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
11			14&15
12	Generalizability	21	Discuss the generalizability (external validity) of the study results
13			16
14	Other information		
15	Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based
16			1
17			

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at <http://www.strobe-statement.org>.

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Association of Acculturation with Cardiac Structure and Function among Hispanic/Latinos: a cross-sectional analysis of the Echocardiographic Study of Latinos

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Manuscripts

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3 **Association of Acculturation with Cardiac Structure and Function among**
4 **Hispanic/Latinos: a cross-sectional analysis of the Echocardiographic Study of Latinos**
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6

7 **Short Title:** Acculturation and Cardiac Structure and Function
8
9

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Abstract

Objective: Hispanics/Latinos, the largest immigrant population in the United States, undergo the process of acculturation and have a large burden of heart failure risk. Few studies have examined the association of acculturation on cardiac structure and function. **Design:** cross-sectional

Setting: the Echocardiographic Study of Latinos

Participants: 1,818 Hispanic adult participants with baseline echocardiographic assessment and acculturation measured by the Short Acculturation Scale, nativity, immigration age, length of US residence, generational status and language.

Primary and secondary outcome measures: Echocardiographic assessment of left atrial volume index (LAVI), left ventricular mass index (LVMI), early diastolic transmitral inflow and mitral annular velocities.

Results: The study population was predominantly Spanish-speaking and foreign-born with mean US residence of 22.7 years, mean age of 56.4 years; 50% had hypertension, 28% had diabetes, and 44% had a BMI $>30\text{kg/m}^2$. Multivariable analyses demonstrated higher LAVI with increasing years of US residence. Foreign-born and first generation participants had higher E/e' but lower LAVI and e' velocities compared to the second generation. Higher acculturation and income $>\$20\text{K}$ were associated with higher LVMI, LAVI, and E/e', but lower e' velocities. Preferential Spanish-speakers with an income $<\$20\text{K}$ had a higher E/e'.

Conclusions: Acculturation was associated with abnormal cardiac structure and function, with some effect modification seen according to socioeconomic status.

Abstract Word Count: 207

Keywords: Acculturation, Echocardiogram, Hispanics/Latinos, Socioeconomic Status

Strengths and limitations of this study

- A population-based cohort study design focusing on the predominantly immigrant Hispanic/Latino population in the United States (US).
- A detailed comprehensive echocardiographic examination was performed to determine cardiac structure and function in every participant.
- By including several acculturation measures (nativity, years of US residence/age at migration, SASH subscales, language preference and generational status) our goal was to be comprehensive and to capture several aspects of acculturation.
- We are specifically referring to acculturation into the US culture, which may not be generalizable to acculturation in other settings.

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3 Cardiovascular disease (CVD) and heart failure (HF) risk factor burden is higher among
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5 Hispanic/Latinos in the United States (US)^{1,2} compared to non-Hispanic whites leading
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7 to abnormalities of cardiac structure and function³ which have been associated with
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10 incident clinical HF,⁴ incident CVD and increased mortality.⁵⁻⁸
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14 With respect to HF, Hispanics/Latinos have a higher incidence compared to non-Hispanic whites and
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16 Hispanics/Latinos who present with HF are younger with more co-morbidities and a lower left
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18 ventricular (LV) ejection fraction (EF) compared to non-Hispanic whites.^{2,9-11} Beyond traditional
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20 HF risk factors (hypertension, diabetes and obesity), sociocultural factors such as acculturation, may
21
22 contribute to HF risk among Hispanic/Latinos (**Figure 1/Conceptual Model**)² but the impact of
23
24 acculturation on cardiac structure and function has not been examined. The fact that
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26 Hispanics/Latinos are the largest immigrant population in the US accentuates the public health
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28 impact of studying the influence of acculturation on cardiac parameters.
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36 Acculturation is a multidimensional process whereby immigrants adapt to the beliefs and
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38 practices of a host culture.¹² This can pose a chronic daily stressor for many immigrants that
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40 can affect physical health outcomes. Higher acculturation levels have been associated with
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42 increased psychosocial stress, deleterious CV health behaviors and a higher CV risk factor
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44 burden.¹³⁻¹⁶ In our mechanistic framework, the acculturative process leads to increase stress
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46 and worse health behaviors which separately or jointly alter cardiac structure and function to
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48 increase HF risk. Few studies^{17,18} have examined acculturation in relation to HF risk
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50 specifically focusing on cardiac structure and function as key intermediary outcomes.
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3 We primarily sought to test whether acculturation, an important sociocultural variable with
4 biopsychosocial implications, is associated with cardiac structure and function among
5 Hispanics/Latinos. Studies of acculturation and CVD often overlook socioeconomic status (SES)
6
7 as an effect modifier. Because SES is associated with cardiac parameters¹⁹ and modifies the
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9 association between acculturation and other health-related variables,²⁰ secondarily, we sought to
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11 test whether our primary associations are moderated by SES.
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19 **Methods**

20 **Cohort Description**

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22 The Hispanic Community Health Study/Study of Latinos (HCHS/SOL) is a population-based
23 study of 16,415 Hispanic/Latinos from randomly selected households at four US field centers
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25 (Bronx, NY; Chicago, IL; Miami, FL; and San Diego, CA).²¹ Probability sampling was used to
26
27 ensure broad representation of the target population and to minimize the sources of bias that may
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29 otherwise enter into the cohort selection and recruitment process. Participants were between 18
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31 and 74 years of age, and self-identified as Cuban, Central American, Dominican, Mexican,
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33 Puerto Rican, or South American Hispanic/Latino heritage. The ECHO-SOL ancillary study was
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35 designed to provide echocardiographic parameters characterizing cardiac structure and function
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37 in a representative HCHS/SOL baseline subsample of 1,818 participants ≥ 45 years old.^{3,22}
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45 Institutional Review Board approval was obtained at each study site (Albert Einstein College of
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47 Medicine, Bronx, NY; Northwestern University, Chicago, Illinois; University of Miami, Miami,
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49 FL; University of California, San Diego, San Diego, CA; Wake Forest School of Medicine,
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51 Winston-Salem, NC) and all ECHO-SOL participants gave informed consent prior to
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53 participating in the study.
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Patient and public involvement

No patients were involved in the development of the research question, design, recruitment or implementation of this research cohort study. Results were disseminated to study participants in the form of a Data Book and periodic newsletters. See www.saludsol.net.

In-Person Examination

The examination protocol for the parent HCHS/SOL has been previously published.¹³ Obesity was defined as a body mass index (BMI) ≥ 30.0 kg/m². Seated resting blood pressures were measured in triplicate and the average of the 2nd and 3rd readings was used for analysis. Type 2 diabetes was defined based on American Diabetes Association definition using one or more of the following criteria: 1) fasting serum glucose ≥ 126 mg/dl, 2) oral glucose tolerance test ≥ 200 mg/dl, 3) self-reported diabetes, 4) HbA1C $\geq 6.5\%$, or 5) taking anti-diabetic medication or insulin. Renal function was measured by estimated glomerular filtration rate (eGFR). Physical activity levels, categorized as low or medium/high, were assessed using the Global Physical Activity Questionnaire.²³ Self-report questionnaires assessed smoking status (no/ever/current), alcohol consumption (current/no), and insurance coverage (yes/no) and type (Private/Medicare/Medicaid). Educational level was defined as highest degree or level of school completed. Current household income while living in the US was dichotomized as $< \$20,000$ and $> \$20,000$, given the low number of participants with incomes $> \$40,000$. Our secondary analysis focused on current income as a more relevant influencer of a participant's acculturative process, acting as a proxy for the ability to integrate and be exposed to mainstream US cultural contexts.

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3 Marital status was categorized as either single, married, partnered, separated, divorced
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5 or widowed.
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10 **Echocardiographic Measurements**

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12 Trained sonographers performed transthoracic echocardiography examinations, including 2D
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14 imaging, and spectral, color and tissue Doppler.²² Echocardiographic measures of left and
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16 right heart structure and function included:
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- 19 1) LV mass index (LVMI) was determined according to guidelines,²⁴ by subtracting the LV
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21 endocardial cavity volume from the LV epicardial volume and multiplying the resultant
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23 myocardial volume by the myocardial density and indexing to body surface area.
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- 26 2) LV systolic function and volumes. LVEF was derived from Volumetric Assessments using
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28 the method of discs from apical 4- and 2-chamber long-axis views to measure end-diastolic
29
30 volume (EDV) and end-systolic volume (ESV). LVEF was calculated: $(EDV - ESV)/EDV$.
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32
- 33 3) LV diastolic function was defined per guidelines,²⁵ using three echocardiographic
34
35 parameters: 1) peak early (E) and late (A) diastolic transmitral inflow velocities; 2) early
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37 diastolic (e') annular velocities (the average of septal and lateral annular velocities were
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39 used); 3) left atrial volume indexed (LAVI) to body surface area.
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- 42 4) Relative Wall Thickness (RWT) predicated LV geometry and was defined as: $[(\text{posterior}$
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44 $\text{LV wall thickness} \times 2) / \text{LV diastolic diameter}]$. Higher RWT values are associated with a
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46 smaller LV cavity size and lower RWT values are associated with higher LV cavity sizes.
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51 **Acculturation Measures**

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3 Acculturation was defined using several validated measures. First, nativity was classified as
4 either born in or outside the US mainland (50 states). Those born in Puerto Rico (PR) or other
5 US territories were classified as born outside of the US mainland to reflect their migration and
6 acculturation experiences. Second, foreign-born individuals were asked the number of years
7 lived in the US and categorized as <5, 5-10, 11-20, >20 years. We used the Short Acculturation
8 Scale for Hispanics (SASH),²⁶ which has two subscales based on five-point Likert type
9 questions: 1. the SASH language subscale (items related to language use [e.g., language they
10 speak, think]); and 2. the SASH social relations subscale (items related to media preference and
11 social affiliations [e.g., language of media programs watched; ethnicity of close friends]). The
12 SASH has yielded reliabilities (α) of 0.92 (overall), 0.90 (language use), 0.86 (media preference),
13 and 0.78 (ethnic and social relations). These subscales were analyzed separately with higher
14 scores representing higher degrees of acculturation. Fifth, language preference was further
15 characterized as English vs. Spanish based on language of interview. Finally, data on
16 generational status (first- and second-generation Hispanics are US-born and distinct from their
17 foreign-born immigrant parents) was collected as well as age at the time of migration to the US.

39 **Statistical Analyses**

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41 Sampling weights were used to obtain weighted frequencies of descriptive variables and
42 population estimates in the ECHO-SOL target population. We used means \pm standard errors
43 (SEs) for continuous variables and proportions for categorical variables. LVMI, RWT, LVEF,
44 e' annular velocities and LAVI were analyzed as continuous variables. LV diastolic dysfunction
45 (LVDD) was analyzed as a binary variable (present vs. absent).³ Acculturation variables were
46 categorical (foreign- vs. US-born; 1st generation vs. 2nd; Spanish language preference vs.
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English), ordinal (<5, 5-10, 11-20, and >20 years in the US) and continuous measures (age at immigration and SASH subscales). Weighted means and linear regression analysis was utilized for continuous variables whereas weighted frequencies and Rao-Scott Chi-Square was utilized for the categorical/ordinal variables. Means were compared across categorical acculturation variables using regression analysis for each dependent variable measure of cardiac structure (LVMI, RWT, LAVI) and function (LVEF, e' , E/e'). Only associations that were statistically significant in unadjusted analyses were further explored in multivariable analysis. Unadjusted and multivariable linear and logistic regression analyses were determined by our continuous and categorical dependent variable, respectively, utilizing sequential modeling for age and sex followed by models including clinical covariates (diabetes, hypertension, and obesity), and behavioral characteristics (physical activity, tobacco use, and alcohol use). For years in the US, we compared >20 years to <5 years as well as an overall comparison across each category of years in the US. We performed a couple of sensitivity analyses (data not shown): 1. comparing acculturative characteristics of individuals born in the island of PR vs. other foreign-born Hispanics; 2. comparing acculturation and health care utilization using HCHS/SOL questions regarding difficulty obtaining health care in the past year and number of physician visits in the past year. We tested effect moderation with income through the use of interaction terms in models followed by stratified analyses by income for statistically significant interactions at the $p < 0.01$ level. All other statistical tests were 2-sided at a significance level of 0.05. All reported values were weighted to account for HCHS/SOL sampling probability design, stratification, clustering and nonresponse and to make estimates applicable to the HCHS/SOL target population. All analyses were performed utilizing SAS 9.3 (SAS Institute, Cary, NC) PROC SURVEY procedures.

Results

Fifty-seven percent of the study population were women; almost half (46%) had a reported annual income under \$20K; over half were married and most had some type of health insurance (mostly Medicaid and/or Medicare). Hypertension and diabetes were prevalent in half and almost one-third of the study population respectively. Most of the study population was foreign-born, only 14% preferred English, almost half (49%) had been in the US >20 years with a mean age of migration of 34 years of age, signifying that the majority came to the US as adults (**Table 1**). Mean values of echocardiographic variables (LAVI, RWT, LVMI, LVEF) were all within normal limits for this study population. However, mean e' annular velocities and E/e' ratio were borderline abnormal. Some degree of diastolic dysfunction was seen in over half (52%) of the study population but this has been previously described.³

Table S1 shows unadjusted relationships between acculturation measures and echocardiographic characteristics. There were statistically significantly higher mean LAVI values across categories of length of time spent in the US whereas RWT appeared to have a U-shaped association. A statistically significantly lower annular relaxation velocity and higher E/e' ratio was seen among the foreign-born compared to US-born and among those 1st generation compared to 2nd generation. Greater acculturation, as measured by higher SASH language scale scores, was associated with greater LAVI. Younger age of migration to US was associated with increased RWT and LAVI.

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3 Adjusted analyses (**Table 2**) demonstrated greater time spent in the US is significantly associated
4 with increased RWT and LAVI. A statistically significantly higher E/e' ratio was seen among the
5 foreign-born participants. Those 1st generation had lower LAVI, lower e' annular velocities and
6 higher E/e' ratios compared to 2nd generation. Higher SASH language scale scores and younger
7 age of migration to US were both associated with increased LAVI. These associations persisted
8 in sequential models adjusted for clinical factors and behavioral factors both separately and
9 together. Although greater odds of LVDD was seen in unadjusted associations with nativity,
10 generational status, SASH language, and age of immigration (**Table 3**), these associations did
11 not persist on adjusted analysis.
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26 Significant interactions ($p < 0.01$) were found between our main exposure (acculturation) and
27 income on the effect of cardiac structure and function. Among those whose annual income is
28 $> \$20K$, a greater number of years in the US was associated with higher LVMI, lower e' annular
29 velocities, and a higher E/e' ratio compared to those making $< \$20K$ annually. Generational status
30 was associated with increased LAVI only among those making $> \$20K$ annually. However, being
31 a preferential Spanish-speaker carried a statistically significant higher E/e' ratio only among
32 those making $< \$20K$ annually. (**Table S2**).
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44 Of foreign-born Hispanics, 24% were born in the US Commonwealth of PR, none in the US Virgin
45 Islands. Spanish language preference was less among Hispanics born in PR compared to other
46 foreign-born Hispanics. PR-born Hispanics scored higher on the SASH language scale and social
47 interaction scale indicating higher acculturation levels compared to other foreign-born Hispanics.
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54 However, the level of Spanish language preference and SASH scores was still lower
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3 among PR-born Hispanics compared to US born Hispanics. With regard to acculturation and
4 health care utilization, being foreign-born, having less years in the US and not having health
5 insurance were all significantly associated with difficulty obtaining health care in the past
6 year. Foreign-born individuals had less physician visits over the past year compared to US
7 born. The relation between years in the US and physician visits was complex, non-linear and
8 mirrored an opposite pattern with income. **(Figure 2)** Having health insurance coverage was
9 significantly associated with more physician visits over the past year.

10 11 12 **Discussion**

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Hispanics/Latinos in the US represent a relatively young demographic such that the future public
health burden of HF as this population ages is potentially underestimated.²⁷ The Hispanic
population >65 years of age is expected to grow 328% between 2000 and 2030, making
Hispanics the fastest growing aging population in the US.²⁸ As the Hispanic population ages,
and HF risk factors and cardiac abnormalities progress, it is likely that an epidemic of HF will
emerge in this population.

Acculturation is a complex but important phenomenon among immigrant populations that
encompasses multiple domains: (1) integration - maintaining the original parent culture while
adopting the host culture; (2) assimilation - rejecting the parent culture and entirely adopting the
host culture; (3) separation - rejecting the host culture and keeping the parent culture; and (4)
marginalization - not identifying with either the original culture or the host culture.²⁹ The
acculturation process can be positive, improved life opportunities in the host culture compared to
the parent culture, and/or it could be negative due to the challenging nature of change and
adaptation to new cultural and social expectations. Prior studies show strong negative effects of

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3 greater acculturation on worsening CV risk factors but positive effects on use of preventive
4 health services.³⁰⁻³² HCHS/SOL has demonstrated significant heterogeneity in CVD risk factor
5 burden among Hispanics/Latinos by country of origin and acculturation measures.¹³ Our
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7
8 analysis of validated acculturation measures provides several important contributions. First,
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11 higher levels of acculturation were associated with abnormal cardiac structure and function in
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13 our predominately foreign-born, Spanish-speaking adult population. Second, different measures
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15 of acculturation (each capturing different aspects of the acculturative process) had varying
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17 associations with different measures of cardiac structure and function (each considered its own
18
19 specific outcome). Finally, income significantly moderated these associations. Our findings
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21 support the premise that exposure to the social and environmental stress of acculturation may
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23 promote unhealthy behaviors³³ and/or act via undefined pathways of physiologic/psychosocial
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25 stress to contribute to the increased HF risk seen among Hispanics/Latinos.²⁷ **(Figure 1)**
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28 Additionally, our sensitivity analysis suggests that living in the island of PR still allows for
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30 maintenance of a culture that is distinct from the US culture. Further elucidating the complexities
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32 of acculturative factors influencing HF risk in immigrant populations is warranted.
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38 Although to our knowledge, there is no existing literature on the association between acculturation
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40 and HF risk, our study found several measures of acculturation (increasing years of US residence,
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42 English preference, and younger age at immigration) were associated with abnormal cardiac
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44 structure and function (increased LAVI, increased LVMI, increased RWT, lower annular e'
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46 relaxation velocity and higher E/e' ratio). Although the magnitudes of our observed associations are
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48 modest, limiting the short-term clinical relevance of these findings, the long-term public health
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50 importance is likely high, given the potential for progression of cardiac
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3 damage with the accumulation of acculturative stress during the life course. This is particularly
4 salient given the fact that abnormal cardiac structure and function is an independent risk factor
5 for the future development of clinical HF. An increased E/e' ratio, LAVI, and LVMI are markers
6 of chronically-elevated filling pressures associated with impaired cardiac relaxation and HF with
7 preserved ejection fraction.^{34,35} The presence of abnormal cardiac structure and function has
8
9 been associated with increased HF hospitalizations, cardiovascular death and improved CV risk
10 prediction.³⁵⁻³⁷ Importantly, these cardiac abnormalities are additive, with worse outcomes seen
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12 in individuals with more than one alteration.³⁵ In order to identify preclinical CV disease,
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14 abnormalities in cardiac structure and function determined by echocardiography are important
15 intermediary measures, many of which have been associated with incident CVD, incident clinical
16 HF and increased mortality.⁵⁻⁷ Given the size of the US Hispanic/Latino population and high
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18 burden of acculturation (82% were foreign-born), echocardiography might help to identify a
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20 particularly high risk subset of participants.
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35 LVM is associated with CVD, sudden cardiac death, and all-cause mortality.³⁴ Among foreign-
36 born Hispanics/Latinos, we found increased LVMI with increasing years in the US. Our study
37 is consistent with prior studies showing a high prevalence of LVM among Hispanics/Latinos
38 especially among low income Hispanics/Latinos with increasing years of US residence.^{18,38,39}
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40 Prior studies have demonstrated that adjustment for socioeconomic factors did not fully account
41 for the presence of increased LVMI among Hispanics/Latinos⁴⁰ possibly due to the residual
42 effect of acculturation. Changes in LVM can occur without overt clinical hypertension in
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44 adrenergic states, such as chronic stress⁴¹ with psychosocial factors such as perceived
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46 discrimination and low social support.^{42,43} Acculturative stress is the psychological impact of
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3 navigating the acculturation process and making decisions on retaining one's native culture while
4 adapting to a new cultural context. Acculturation as a chronic stressor may negatively affect
5 mental and physical health through unhealthy behaviors,^{31,33} increased anxiety, depression,
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7 perceived discrimination and lack of social support^{15,33,44} all of which may impact adrenergic
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9 biomarkers leading to cardiac structural and functional abnormalities and increased HF risk
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11 observed in our study. This is an area of research to further explore in future studies.
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19 The statistically significant interaction between acculturation and SES on cardiac measures may
20 shed light on the "Hispanic paradox" which states that Hispanics/Latinos, a disproportionately
21 low SES group, have lower overall mortality and cardiovascular mortality compared to non-
22 Hispanic Whites.² Low SES is a composite chronic stressor encompassing multiple factors (e.g.,
23 work, housing and financial strain). Longitudinal studies have shown an inverse association
24 between SES level and adverse outcomes.^{42,45} We hypothesized that less acculturation (more
25 retention of the parent culture) may be protective of the adverse health consequences of low SES.
26 In our study, those with higher SES (defined as annual incomes >\$20K) exhibited more
27 deleterious effects of increasing acculturation on cardiac structural and functional measures. A
28 prior study found the relationship between acculturation and health care utilization to be complex
29 and moderated by SES.⁴⁶ Our exploratory analysis found that being foreign-born and having a
30 higher income may make one less likely to utilize health care. A more extensive analysis on the
31 complex nature of acculturation and health care utilization is beyond the scope of our paper but
32 this area deserves further consideration in future studies. There may be more acculturative stress
33 for higher-SES immigrants, perhaps through increased contact and interaction with the
34 mainstream culture,⁴⁷ which may contribute to our findings. *Familismo* is a culture-specific
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3 factor characterized by having strong bonds with nuclear and extended family resulting in a high
4 level of perceived family support and is associated with indicators of improved health.^{48,49}
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7 Studies suggest that with increasing acculturation, *familismo* is eroded and dimensions of
8
9 *familismo* begin to increase psychosocial stress rather than alleviate it.⁴⁹⁻⁵¹
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14 Several limitations should be noted. Our study is cross-sectional and precludes the ability to
15 assess the temporal sequence of the relationships and causal inference. However, our findings
16 warrant replication and longitudinal follow up. Participants resided in one of four US cities,
17 precluding generalizability to all Hispanic/Latinos in the US. While this study is one of the
18 largest studies of acculturation with cardiac structure and function in any population, the sample
19 size is relatively modest; thus, we were underpowered to perform stratified analyses by national
20 origin in order to characterize the heterogeneity within Hispanic/Latinos. We are specifically
21 referring to acculturation into the US culture, which may not be generalizable to acculturation in
22 other settings. Finally, our study focuses on acculturation as a unique intra-ethnic phenomenon.
23 By including several measures (nativity, years of US residence/age at migration, SASH
24 subscales, language preference and generational status) our goal was to be comprehensive and
25 to capture several aspects of acculturation. We believe acculturation cannot be captured by just
26 one measure, as has been done in much of the prior literature; however, we agree that even our
27 multivariable approach may not fully capture the complexities of all aspects and dimensions of
28 the acculturative process.
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51 **Conclusions**

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3 In addition to traditional CV risk factors, acculturation may explain the disproportionate burden
4 of HF risk among Hispanics/Latinos. Our study found significant deleterious associations
5 between several acculturation measures with cardiac structural and functional parameters among
6 a predominantly low-SES, foreign-born Hispanic/Latino population with increasing years of
7 residence in the US. The acculturation experience is not unique to Hispanics/Latinos. Our study
8 may help generate further research in other immigrant populations. Further elucidation of how
9 acculturation impacts HF risk is warranted in order to possibly risk stratify a high-risk subgroup
10 of Hispanics/Latinos and to inform the development of culturally appropriate interventions to
11 amplify protective factors and to make the acculturative process less deleterious for
12 Hispanics/Latinos and other immigrants.
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Data sharing statement: The data are available according to NIH/HLBI data sharing policies through the NHLBI BioLINCC repository or through the HCHS/SOL Data Coordinating Center on request.

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Table 1. ECHO-SOL Demographic and Clinical Characteristics (N = 1,818)†

Demographic Characteristics	[N (%)]
Women	1187 (57.4)
Age, [mean (SE)]	56.4 (0.37)
High School Graduate or Higher	726 (43.3)
Annual Family Income > \$20,000	787 (45.5)
Marital Status	
Single	332 (18.8)
Married/Partner	961 (53.2)
Separated/Divorced/Widow	522 (28.0)
Health Insurance	1042 (60.1)
Short Acculturation Scale for Hispanics (SASH)	[mean (SE)]
Language Use Subscale	1.7 (0.05)
Social Relations Subscale	2.1 (0.03)
Length of US residence	[N (%)]
<5 years	178 (13.6)
5-10 years	247 (15.2)
11-20	385 (22.1)
>20	842 (49.1)
Second generation or higher	185 (9.3)
English language preference	225 (14.0)
Age at migration [mean (SE)]	34.0 (1.0)
US born	163 (7.9)
Clinical Characteristics	[N (%)]
Hypertension	861 (50.0)
Type 2 Diabetes	523 (28.4)
Current Smoker	304 (17.6)
Physical activity level low	1227 (67.3)
BMI ≥ 30	822 (44.3)
Current Alcohol Use	770 (43.5)
Echocardiographic Variables	[mean (SE)]
Left Atrial Volume Index (<33 mL/m ²)	23.0 (0.25)
Relative Wall Thickness (0.22-0.42)	0.40 (0.004)
Left Ventricular Mass Index (45-105 g/m ²)	82.7 (0.7)
Ejection Fraction (≥ 55 %)	59.8 (0.2)
E prime (e') (8-16 cm/s)	8.1 (0.09)
E/e' (≤ 12)	10.0 (0.12)
Diastolic Dysfunction [N (%)]	916 (51.9)

†N's presented are unweighted counts of total participants in the ECHO-SOL with each respective characteristic.

Percentages are weighted row percentages.

Normal values are provided for cardiac structure and function variables.

Table 2. Adjusted Analyses of Acculturation Measures with Cardiac Structure and Function.*

	LVMI (g/m ²) β (p)	RWT β (p)	LAVI (mL/m ²) β (p)	LVEF (%) β (p)	e' (cm/s) β (p)	E/e' β (p)
Nativity						
Age, sex	—	—	—	—	-0.349 (0.12)	0.571 (0.02)
Model 1	—	—	—	—	-0.320 (0.10)	0.524 (0.02)
Model 2	—	—	—	—	-0.324 (0.14)	0.532 (0.02)
Model 3	—	—	—	—	-0.303 (0.12)	0.503 (0.02)
Foreign Born (Years in the US)						
Age, sex	—	0.020 (0.06); all (0.03)	1.57 (0.02); all (<0.05)	—	—	—
Model 1	—	0.022 (0.02); all (0.02)	1.63 (0.02); all (<0.05)	—	—	—
Model 2	—	0.018 (0.06); all (0.02)	1.55 (0.02); all (0.05)	—	—	—
Model 3	—	0.021 (0.02); all (0.007)	1.71 (0.01); all (0.04)	—	—	—
Generation						
Age, sex	—	—	-0.468 (0.21)	—	-0.529 (0.01)	0.710 (0.002)
Model 1	—	—	-1.797 (0.004)	—	-0.447 (0.01)	0.594 (0.003)
Model 2	—	—	-1.444 (0.03)	—	-0.499 (0.01)	0.671 (0.003)
Model 3	—	—	-1.584 (0.01)	—	-0.425 (0.02)	0.575 (0.006)
SASH Language						
Age, sex	—	—	0.580 (0.01)	—	0.125 (0.10)	—
Model 1	—	—	0.610 (0.008)	—	0.097 (0.11)	—
Model 2	—	—	0.546 (0.01)	—	0.123 (0.15)	—
Model 3	—	—	0.590 (0.007)	—	0.095 (0.16)	—
Age at Immigration						
Age, sex	—	0.0005 (0.15)	-0.040 (0.008)	—	-0.005 (0.27)	—
Model 1	—	0.0005 (0.13)	-0.040 (0.008)	—	-0.006 (0.14)	—
Model 2	—	0.0004 (0.15)	-0.038 (<0.001)	—	-0.005 (0.37)	—
Model 3	—	0.0004 (0.13)	-0.038 (0.01)	—	-0.005 (0.22)	—

*Only acculturation measures that were significant in unadjusted analyses were analyzed in multivariable adjusted models.

For Years in the US, the 1st p-value reflects <5 years vs. >20 years comparison; whereas the 2nd p-value is for overall comparison across all the Years in the US categories (<5; 5-10; 11-20; >20) Model 1: Age, Sex, Diabetes, Hypertension, Obesity | Model 2: Age, Sex, Physical Activity, Tobacco, Alcohol Use | Model 3: Model 1 + Model 2

LVMI = Left ventricular mass index; RWT = Relative wall thickness; LAVI = Left atrial volume index; LVEF = Left ventricular ejection fraction

e' = Mitral annular early diastolic velocity; E/e' = Ratio between early mitral inflow velocity and mitral annular early diastolic velocity

Table 3. Unadjusted and Adjusted[‡] Analyses of Acculturation Measures with Diastolic Dysfunction.

		Adjusted Sequential Models			
	Unadjusted	Age, Sex	Model 1	Model 2	Model 3
Nativity					
Foreign born	1.67 (1.08-2.58)	0.98 (0.62-1.55)	0.94 (0.59-1.51)	0.98 (0.62-1.55)	0.95 (0.59-1.53)
US born	Ref				
Years in the US					
<5	0.86 (0.60-1.24)	—	—	—	—
5-10	0.72 (0.49-1.04)				
11-20	0.91 (0.61-1.37)				
>20	Ref				
Generation					
1	1.90 (1.24-2.92)	1.29 (0.77-2.14)	1.18 (0.74-1.91)	1.26(0.77-2.06)	1.18 (0.73-1.89)
2	Ref				
Language Preference					
English	0.67 (0.34-1.32)	—	—	—	—
Spanish	Ref				
SASH Language	0.81 (0.67-0.98)	—	—	—	—
SASH Social	0.88 (0.68-1.15)	—	—	—	—
Age at Immigration	1.02 (1.004-1.03)	1.00 (0.99-1.02)	1.01 (0.995-1.02)	1.01 (0.99-1.02)	1.01 (0.995-1.02)

[‡]Only acculturation measures that were significant in unadjusted analyses were analyzed in adjusted models.

ORs (95% CIs) are presented

Model 1: Age, Sex, Diabetes, Hypertension, Obesity

Model 2: Age, Sex, Physical Activity, Tobacco, Alcohol Use

Model 3: Model 1 + Model 2

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3 Figure Legend:
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6 Figure 1. Proposed Relationships Between Acculturation with Cardiac Structure and Function.
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8 Figure 2. Relation of Years Residing in the US or Income Level with Number of Physician Visits
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Figure 1.

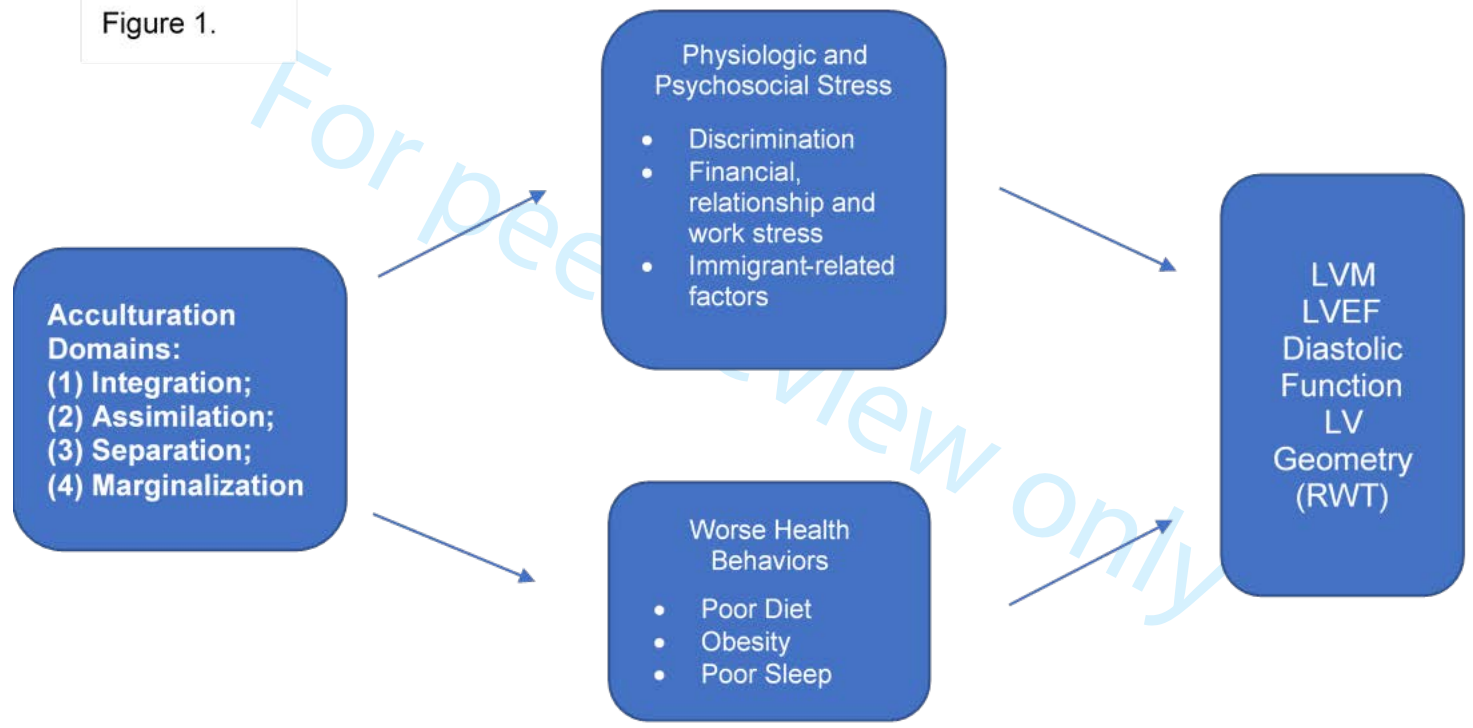
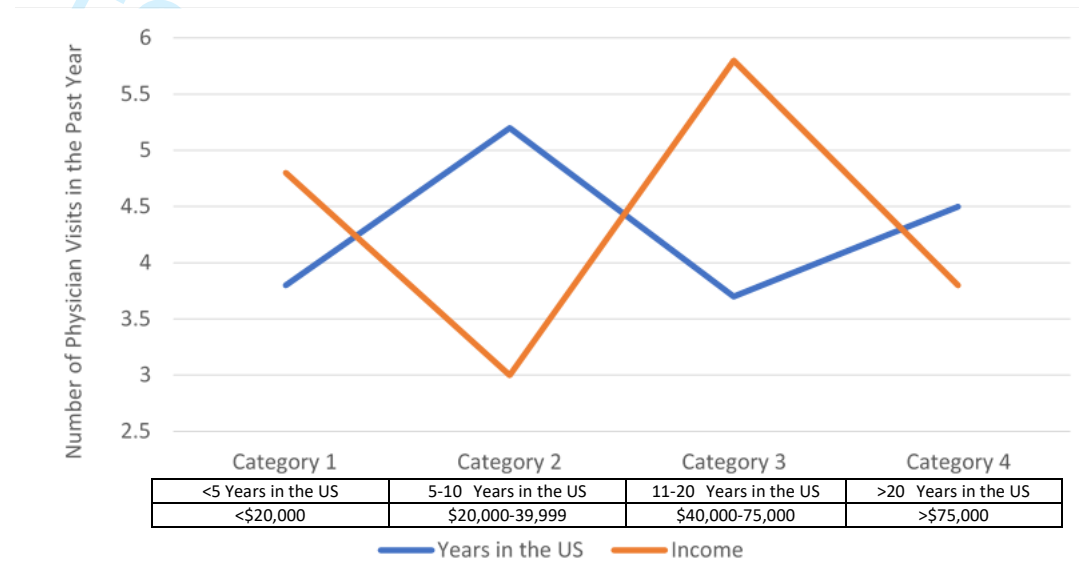


Figure 2.



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Table S1. Unadjusted Acculturation Measures with Echocardiographic Measures of Cardiac Structure and Function.

	LVMI (g/m ²)		RWT		LAVI (mL/m ²)		LVEF (%)		e' (cm/s)		E/e'	
Categorical Measures												
	Mean	p	Mean	p	Mean	p	Mean	p	Mean	p	Mean	p
Nativity												
Foreign Born	82.74	0.92	0.40	0.07	22.93	0.10	59.83	0.54	7.98	<0.001	10.1	<0.001
US Born	82.54		0.38		24.10		59.50		8.99		8.8	
Years in US												
<5 years	79.80	0.16	0.41	0.03	21.70	0.03	59.94	0.09	7.71	0.11	10.2	0.25
5-10 years	80.43		0.39		22.40		60.04		8.18		9.7	
11-20 years	83.60		0.41		22.82		58.94		8.27		9.8	
>20 years	83.96		0.39		23.50		60.14		7.86		10.2	
Generation												
First	82.69	0.88	0.40	0.08	22.89	0.02	59.84	0.45	7.97	<0.001	10.1	<0.001
Second or Greater	82.96		0.38		24.41		59.45		9.01		8.8	
Language												
English	81.51	0.59	0.38	0.08	24.00	0.06	60.13	0.48	8.52	0.15	9.7	0.64
Spanish	82.92		0.40		22.87		59.75		7.99		10.0	
Continuous Measures												
	β (se)	p	β (se)	p	β (se)	p	β (se)	p	β (se)	p	β (se)	p
Age at Immigration	-0.0003 (0.0632)	0.99	0.0006 (0.0003)	0.02	-0.030 (0.014)	0.03	-0.003 (0.012)	0.79	-0.023 (0.007)	0.001	0.012 (0.010)	0.23
SASH Subscales												
Language	0.087 (0.735)	0.91	-0.005 (0.003)	0.10	0.539 (0.237)	0.02	0.166 (0.180)	0.36	0.255 (0.098)	0.009	-0.205 (0.109)	0.06
Social Relations	0.086 (1.392)	0.95	-0.009 (0.006)	0.15	0.732 (0.373)	0.05	0.539 (0.295)	0.07	0.266 (0.155)	0.09	-0.156 (0.217)	0.47

LVMI = Left ventricular mass index; RWT = Relative wall thickness; LAVI = Left atrial volume index

LVEF = Left ventricular ejection fraction; e' = Mitral annular early diastolic velocity

E/e' = Ratio between early mitral inflow velocity and mitral annular early diastolic velocity

Table S2. Income Stratified Adjusted Analyses of Acculturation Measures with Cardiac Structure and Function.[‡]

	LVMI (g/m ²)				LAVI (mL/m ²)				e' (cm/s)				E/e'				Diastolic Dysfunction	
	<\$20,000		>\$20,000		<\$20,000		>\$20,000		<\$20,000		>\$20,000		<\$20,000		>\$20,000		<\$20,000	>\$20,000
	Mean	p	Mean	p	Mean	p	Mean	p	Mean	p	Mean	p	Mean	p	Mean	p	ORs (95% CI)	ORs (95% CI)
Nativity																		
Foreign	—	—	—	—	—	—	—	—	7.90	0.0006	8.24	0.048	—	—	—	—	1.67 (0.89-	1.24 (0.70-
US born									8.83		8.99						3.14)	2.19)
Years in the US																		
<5	80.02		73.35						7.70		9.03		10.20		9.17			
5-10	81.32	0.15	79.38	0.002	—	—	—	—	7.72	0.27	8.87	0.001	10.36	0.62	8.63	0.003	—	—
11-20	82.22		86.12						8.23		8.56		9.912		9.49			
>20	85.73		82.23						7.87		7.89		10.28		10.16			
Generation																		
1	—	—	—	—	23.04	0.45	22.85	0.02	—	—	—	—	—	—	—	—	1.82 (0.99-	1.50 (0.83-
2					23.91		24.67										3.34)	2.69)
Language Preference																		
English	—	—	—	—	—	—	—	—	—	—	—	—	9.42	0.01	10.00	0.63	—	—
Spanish													10.21		9.55			
	β	p	β	p	β	p	β	p	β	p	β	p	β	p	β	p	—	—
SASH Language	—	—	—	—	0.2686	0.32	0.7213	0.04	—	—	—	—	-0.3026	0.003	0.1065	0.60	—	—
SASH Social	—	—	—	—	—	—	—	—	—	—	—	—	-0.5410	0.008	0.4641	0.27	—	—

[‡]Only statistically significant interactions were analyzed in adjusted models; excludes cases where income is missing.
 Multivariable models were adjusted for Age, Sex, Diabetes, Hypertension, Obesity, Physical Activity, Tobacco, and Alcohol Use.
 LVMI = Left ventricular mass index; LAVI = Left atrial volume index
 e' = Mitral annular early diastolic velocity; E/e' = Ratio between early mitral inflow velocity and mitral annular early diastolic velocity

STROBE Statement—Checklist of items that should be included in reports of *Observational studies in epidemiology*

	Item No	Recommendation	Page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1&
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	3&4
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any pre-specified hypotheses	4&5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	5
		(b) For matched studies, give matching criteria and number of exposed and unexposed	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6&7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6&7
Bias	9	Describe any efforts to address potential sources of bias	8
Study size	10	Explain how the study size was arrived at	5&9
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6&7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	8&9
		(b) Describe any methods used to examine subgroups and interactions	
		(c) Explain how missing data were addressed	
		(d) If applicable, explain how loss to follow-up was addressed	
		(e) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	Report numbers of outcome events or summary measures over time	10&11
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10&11
		(b) Report category boundaries when continuous variables were categorized	
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a	

1		meaningful time period	
2	Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
3			11
4			
5	Discussion		
6	Key results	18	Summarise key results with reference to study objectives
7			12&13
8	Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
9			16
10	Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
11			14&15
12	Generalizability	21	Discuss the generalizability (external validity) of the study results
13			16
14	Other information		
15	Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based
16			1
17			

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at <http://www.strobe-statement.org>.