Burden of Systolic and Diastolic Left Ventricular Dysfunction Among Hispanics in the United States
Insights From the Echocardiographic Study of Latinos

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Background—Population-based estimates of cardiac dysfunction and clinical heart failure (HF) remain undefined among Hispanics/Latino adults.

Methods and Results—Participants of Hispanic/Latino origin across the United States aged 45 to 74 years were enrolled into the Echocardiographic Study of Latinos (ECHO-SOL) and underwent a comprehensive echocardiography examination to define left ventricular systolic dysfunction (LVSD) and left ventricular diastolic dysfunction (LVDD). Clinical HF was defined according to self-report, and those with cardiac dysfunction but without clinical HF were characterized as having subclinical or unrecognized cardiac dysfunction. Of 1818 ECHO-SOL participants (mean age 56.4 years; 42.6% male), 49.7% had LVSD or LVDD or both. LVSD prevalence was 3.6%, whereas LVDD was detected in 50.3%. Participants with LVSD were more likely to be males and current smokers (all \( P < 0.05 \)). Female sex, hypertension, diabetes mellitus, higher body mass index, and renal dysfunction were more common among those with LVDD (all \( P < 0.05 \)). In age–sex adjusted models, individuals of Central American and Cuban backgrounds were almost 2-fold more likely to have LVDD compared with those of Mexican backgrounds. Prevalence of clinical HF with LVSD (HF with reduced EF) was 7.3%; prevalence of clinical HF with LVDD (HF with preserved EF) was 3.6%. 96.1% of the cardiac dysfunction seen was subclinical or unrecognized. Compared with those with clinical cardiac dysfunction, prevalent coronary heart disease was the only factor independently associated with subclinical or unrecognized cardiac dysfunction (odds ratio: 0.1; 95% confidence interval: 0.1–0.4).

Conclusions—Among Hispanics/Latinos, most cardiac dysfunction is subclinical or unrecognized, with a high prevalence of diastolic dysfunction. This identifies a high-risk population for the development of clinical HF. (Circ Heart Fail. 2016;9:e002733. DOI: 10.1161/CIRCHEARTFAILURE.115.002733.)

Key Words: diastolic dysfunction echocardiography ■ echocardiography ■ heart failure ■ Hispanics ■ systolic dysfunction

Cardiac dysfunction is an important and independent risk factor for the future development of clinical heart failure (HF). Early recognition and treatment of American College of Cardiology Foundation/American Heart Association stage B HF, defined as cardiac dysfunction without signs or symptoms of HF, is a potentially powerful strategy to prevent progression to American College of Cardiology Foundation/American Heart Association stage C or D HF, defined as clinical or symptomatic HF. Unfortunately, current population-based estimates of cardiac dysfunction are based on studies that did not include Hispanics/Latinos.

See Clinical Perspective

Hispanics/Latinos are particularly vulnerable to cardiac dysfunction for several reasons: (1) Hispanics/Latinos have increased prevalence of HF risk factors (stage A HF) with...
higher rates of diabetes mellitus (both diagnosed and undiagnosed), obesity, and hypertension; (2) Hispanics/Latinos have an almost 2-fold higher prevalence of structural heart disease (stage B HF) with high rates of left ventricular (LV) hypertrophy and abnormal LV geometry. A high prevalence of stage A and stage B HF predetermines to higher rates of cardiac dysfunction. (3) Hispanics/Latinos are unfavorably affected by health disparities, such as undertreated diabetes mellitus and hypertension. Furthermore, the Hispanic/Latino population >65 years of age is expected to grow 328% between 2000 and 2030. As the Hispanic/Latino population ages, it is likely that an epidemic of cardiac dysfunction and clinical HF among Hispanics/Latinos will emerge.

Because of under-representation in prior community-based HF cohorts, few studies have highlighted the prevalence of cardiac dysfunction among Hispanics/Latinos. Our objective was to establish the prevalence of the 2 components of cardiac dysfunction—LV systolic dysfunction (LVSD) and LV diastolic dysfunction (LVDD)—as well as self-reported clinical HF, in a large representative community-based cohort of US Hispanic/Latino adults.

Methods

The Hispanic Community Health Study/Study of Latinos (HCHS/SOL) is a prospective, population-based study of the prevalence of multiple health conditions and their risk factors among 164,154 diverse Hispanic/Latino individuals aged 18 to 74 years and residing in 4 US metropolitan areas, the Bronx, NY; Chicago, IL; Miami, FL; and San Diego, CA. Participants included Hispanics/Latinos who self-identified as Cuban, Central American, Dominican, Mexican, Puerto Rican, and South American heritage. Probability sampling was used to ensure a broad representation of the target population and to minimize the various sources of bias that may otherwise enter into the cohort selection and recruitment process. Ineligibility criteria for the HCHS/SOL included being on active military service, not currently living at home, planning to move from the area in the next 6 months, unable to complete the study in English or Spanish, or unable to attend the clinic examination.

The Echocardiographic Study of Latinos (ECHO-SOL), an ancillary study to the HCHS/SOL, was designed to provide echocardiographic parameters characterizing cardiac structure and function in a representative HCHS/SOL subsample. ECHO-SOL used a stratified random sampling design to assure that ECHO-SOL represents not only the overall HCHS/SOL population, but also the major Hispanic/Latino background group distribution found in HCHS/SOL. A detailed description of the design, rational, and methods has been described elsewhere. Across all ECHO-SOL sites, enrollment was conducted from October 2011 to June 2014 with participation rates averaging 80% among eligible participants. The Institutional Review Board at the Wake Forest School of Medicine and at each study site provided approval and oversight of all study materials and activities. All ECHO-SOL participants gave informed consent.

Echocardiographic Measurements

A standardized echocardiography ultrasound examination, including M-mode, 2-dimensional, spectral, color flow, and tissue Doppler, was performed by experienced Registered Diagnostic Cardiac Sonographers at each of the 4 parent study field sites using Philips IE-33 or Sonos 7500 scanners interfaced with a standard 2.5- to 3.5-MHz phased-array probe, according to American Society of Echocardiography (ASE) recommendations. Echocardiograms were analyzed and interpreted centrally at Wake Forest School of Medicine (Winston-Salem, NC). All ECHO-SOL echocardiograms were read by a certified technical reader and over-read by a board-certified cardiologist with expertise in echocardiography (Dr Rodriguez). Over-reads of echocardiograms were performed to confirm the accuracy of key quantitative measurements and to identify clinically important findings. Inter- and intrareader reproducibility was assessed and previously reported. For inter-reader reproducibility, intraclass correlation values ranged from 0.80 to 0.99 with left atrial volume and LV end-diastolic volumes having the highest intraclass correlation values (0.97–0.99). Intraclass correlation values were slightly better than intrareader assessments for all measures.

LVSD was assessed using LV ejection fraction (LVEF) derived from volumetric assessments and defined as LVEF <50%. Two-dimensional imaging of the LV was performed to obtain the best possible images of the LV endocardium without foreshortening of the LV cavity or echo drop out. Using the apical 4- and 2-chamber views, LV end-diastolic (EDV) and end-systolic volumes were derived using biplane method of discs, as per the ASE-recommended methodology. The modified Simpson’s rule states that the volume of a 3-dimensional structure can be determined by dividing the structure into a sequence of 2-dimensional slices (or discs) and then summing the product of the cross sectional area and thickness of each disc. EF was calculated from EDV and end-systolic volume estimates using the following formula: LVEF = (EDV − end-systolic volume)/EDV. LVEF could not be ascertained in 4.9% of the cohort because of image quality.

Echocardiographic assessment of LVDD included (1) pulse-wave Doppler performed in the apical 4-chamber view with the sample volume placed in the mitral valve orifice at the level of the leaflet tips to obtain peak early (E) and late (A) diastolic transmural inflow velocities; (2) tissue Doppler imaging to acquire mitral early diastolic (e‘) and late (a‘) diastolic annular velocities from the apical 4-chamber view. We used the average of 3 consecutive beats. LVDD was classified as having isolated LVDD if the ratio of e‘/a‘ was >1.5, or if the ratio of mitral inflow peak early (E) to late (A) diastolic transmitral inflow velocity was >1.5. Diastolic dysfunction was assessed using ASE guidelines and grading algorithm. LVDD was graded I (mild), II (moderate), or III (severe; Figure 1). Our grading algorithm was developed using a combination of published ASE and Redfield definitions. For the analysis of LVDD, we excluded participants with unclassifiable or indeterminate LVDD (n=32; 1.8%), current pregnancy (n=2; 0.1%), EDV indexed to body surface area >97mL/m2 (n=1; 0.05%), atrial fibrillation by ECG (n=2; 0.1%), moderate or severe left-sided valvular disease (n=20; 1.1%), or LVEF <50% or missing (n=149; 8.2%); hence, participants classified as having LVDD had isolated LVDD and no LVSD. Abnormal isovolumetric relaxation time was defined as isovolumetric relaxation time outside of the range of 0.06 to 0.1 s. Abnormal LV stroke volume was defined as LV stroke volume <55 mL, and abnormal E/e‘ was defined as value >10.

Clinical Covariates

Methods for HCHS/SOL baseline clinical parameters have been previously described. Briefly, trained personnel administered a standardized questionnaire assessing participant sociodemographic characteristics, such as age, sex. Socioeconomic status was assessed using information collected on educational attainment and income. Self-report questionnaires were used to assess whether participants have ever smoked or were current smokers, as well as whether they have ever been diagnosed with HF by a healthcare provider. Coronary heart disease (CHD) was defined as history of angina, myocardial infarction or revascularization, and ECG evidence of old myocardial infarction. Physical activity levels were assessed using the Global Physical Activity Questionnaire to collect information on physical activity participation in 3 settings (work, travel, and leisure). Low, medium, and high physical activity categories were defined based on type of physical activity and time spent on each specific activity. Information on both prescription and over-the-counter medications used by participants in the 4 weeks preceding the examination date was obtained via scanning of medication package bar code symbols, transcription of pill bottle labels, and survey interviews. Trained technicians measured each participant’s height and weight twice and then averaged these 2 measures to calculate body mass index (BMI=weight [kg]/height [m]²). Participants with BMI of ≥30 kg/m² are categorized as obese. Medical personnel measured
resting systolic and diastolic blood pressures using a standardized protocol. Hypertension was defined as a systolic blood pressure of \( \geq 140 \text{ mmHg} \), diastolic blood pressure of \( \geq 90 \text{ mmHg} \), the participant’s self-report of a history of hypertension, or if the patients were on antihypertensive treatment. Participants were classified as having hypercholesterolemia if they were currently using cholesterol-lowering medication, had low-density lipoprotein levels \( \geq 160 \text{ mg/dL} \) or total cholesterol \( \geq 240 \text{ mg/dL} \). Type 2 diabetes mellitus was defined based on American Diabetes Association definition using one or more of the following criteria: (1) fasting serum glucose \( \geq 126 \text{ mg/dL} \), (2) oral glucose tolerance test \( \geq 200 \text{ mg/dL} \), (3) self-reported diabetes mellitus, (4) hemoglobin A1C \( \geq 6.5\% \), or (5) taking anti-diabetic medication or insulin. Renal disease was defined as an estimated glomerular filtration rate \( < 60 \text{ mL/min} \).

The prevalence of HF was assessed based on self-reported history of physician-diagnosed clinical HF. Participants with no HF diagnosis but with either diastolic or systolic cardiac dysfunction at echocardiography were considered to have subclinical or unrecognized diastolic or systolic dysfunction. This designation does not imply that the participant did not have symptoms, only that the participant had not sought evaluation or had not had an evaluation that resulted in a diagnosis of HF. Participants with a clinical HF history and LVEF \( < 50\% \) or \( > 50\% \) were classified as HF with reduced EF (HFrEF) or HF diagnosis of HF. Participants with a clinical HF history and LVEF not sought evaluation or had not had an evaluation that resulted in a diagnosis of HF. Participants with a clinical HF history and LVEF \( < 50\% \) or \( > 50\% \) were classified as HF with reduced EF (HFrEF) or HF diagnosis of HF.

Covariates of interest included age, sex, BMI, hypertension, diabetes mellitus, hypercholesterolemia, renal disease, prevalent coronary heart disease, physical activity, current tobacco use, current alcohol use, educational level, income level, health insurance status, and study site.

Prevalence estimates of subclinical or unrecognized LVSD, LVDD, and cardiac dysfunction were determined. Logistic regression models assessed the association of different variables with the presence of subclinical or unrecognized LVSD, LVDD, and cardiac dysfunction. Sequential logistic regression models (unadjusted; age-sex adjusted; then fully adjusted models) assessed the association of Hispanic/Latino background group as a predictor of LVSD, LVDD, and cardiac dysfunction as separate outcomes after adjustment for all covariates of interest listed earlier. Additional exploratory analysis assessed age-adjusted prevalence estimates of LVSD, LVDD, and cardiac dysfunction by center and Hispanic/Latino background groups. Sampling weights and survey statistics were used for all analyses. All analyses were weighted to adjust for sampling probability and nonresponse. All analyses were conducted using SAS v. 9.3 (SAS Institute, Inc., Cary, NC).

**Results**

Seventy-nine percent of the ECHO-SOL study population was under age 65, and predominantly 57.4% were female (Table 1). Almost half were obese. Half of the study participants had hypertension, and over two thirds had either pre-diabetes mellitus or diabetes mellitus. Renal disease by estimated glomerular filtration rate was present in 6.4%, whereas prevalent CHD was reported in 18%. More than two thirds reported low levels of physical activity. Almost one fifth of participants were current smokers, and over 40% were current drinkers. Over a third reported having less than high school education, and over half reported annual incomes below $20,000 (Table 1). Only 6.9% of the participants had abnormal left atrial volume index. With regard to functional indices, \( e/e' \) and LV stroke volume were abnormal in almost half of the cohort, whereas isovolumetric relaxation time was abnormal in almost a third of participants.

**Systolic Dysfunction**

LVEF was obtained in \( \approx 95\% \) of participants with a mean LVEF of 59.8% (±0.2). LVEF was essentially the same among participants with a history of clinical HF versus those without

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**Figure 1.** Algorithm for assessing left ventricular diastolic dysfunction (LVDD) via echocardiography based on the Redfield and American Society of Echocardiography (ASE) criteria. For LVDD assessment, we excluded participants with atrial fibrillation, more than mild mitral valvular disease, left ventricular ejection fraction (LVEF) \( < 50\% \), or left ventricular end-diastolic volume (LVEDV) >97 mL/m². LAVi indicates left atrial volume index.
LVSD was prevalent in 60 (3.6%) cohort members. Prevalence of LVSD was significantly higher among men compared with women across all age groups and did not increase significantly with older age (Table 2). In multivariable models, female sex and current tobacco smoking were the only factors independently associated with LVSD. LVSD did not vary by age, BMI, hypertension, diabetes mellitus, high cholesterol, renal disease, prevalent heart disease, physical activity, alcohol use, educational level, income, or health insurance status (Table 3).

### Diastolic Dysfunction

Diastolic function was classified as abnormal in 817 (50.3%) participants; 16.1% had mild (grade I), 32.7% had moderate (grade II), and 1.5% had severe (grade III) LVDD (Table 1). The prevalence of LVDD increased significantly with age and was significantly higher in women versus men. Sex differences persisted across age groups, except in those 65+ years of age, LVDD prevalence became similar among men and women (Table 2). In fully adjusted models, age, male sex, BMI, hypertension, diabetes mellitus, and renal disease were independently associated with the presence of LVDD (Table 3).

### Cardiac Dysfunction (LVSD and LVDD)

Because some participants with LVSD also had LVDD, there is overlap seen within participants classified as having LVSD, LVDD, and cardiac dysfunction (Figure 2A). Among our community cohort of Hispanics/Latinos, the prevalence of cardiac dysfunction was high, with 49.7% of participants having either LVSD or LVDD. The prevalence of cardiac dysfunction was somewhat higher in women and increased with older age, particularly among men compared with women (Table 2). Having health insurance was associated with less prevalent cardiac dysfunction in unadjusted models. Only age, hypertension, BMI, and diabetes mellitus were independently associated with the presence of cardiac dysfunction (all $P<0.05$; Table 3).

### Subclinical or Unrecognized Cardiac Dysfunction

Self-reported clinical HF prevalence was 4.4% (n=64). Among participants with cardiac dysfunction, Figure 2B shows the prevalence of clinical and subclinical cardiac dysfunction. Even though self-reported clinical HF was more common among those with an abnormal LVEF (HFrEF) than those with an LVEF >50% (HFpEF; 7.3% versus 3.6%, respectively), the more prevalent clinical HF was HFpEF. Among those with self-reported HF, 53 (93.6%) participants had an EF >50%. The prevalence of self-reported HF did not significantly vary with age, sex, or Hispanic/Latino background group (all $P>0.19$), but did vary by insurance status ($P<0.01$). Of all participants with cardiac dysfunction, 94.7% had subclinical or unrecognized cardiac dysfunction. The proportion of subclinical or unrecognized cardiac dysfunction did not differ when looking at LVSD or LVDD separately (Table 4). Of all participants with subclinical or unrecognized cardiac dysfunction, 19.5% were taking angiotensin-converting enzyme inhibitor, 14.2% were on a β-blocker, and 15.6% on diuretics as opposed to 33.5%, 36.9%, and 30.0%, respectively, among those with clinical cardiac dysfunction (all $P<0.01$). In

### Table 1. Baseline Characteristics*

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>N (%)</th>
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<tbody>
<tr>
<td>Age, mean</td>
<td>56.3±0.37</td>
</tr>
<tr>
<td>Age, &gt;65 y</td>
<td>214 (21.0)</td>
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<tr>
<td>Male</td>
<td>631 (42.6)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>861 (50.0)</td>
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<tr>
<td>Diabetes mellitus</td>
<td>523 (28.4)</td>
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<tr>
<td>Hypercholesterolemia</td>
<td>711 (40.2)</td>
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<tr>
<td>Renal disease</td>
<td>106 (6.40)</td>
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<tr>
<td>Heart disease</td>
<td>303 (18.00)</td>
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<tr>
<td>Heart failure</td>
<td>64 (4.30)</td>
</tr>
<tr>
<td>Low physical activity</td>
<td>1227 (67.30)</td>
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<tr>
<td>Body mass index, mean</td>
<td>30.1±0.22</td>
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<tr>
<td>Body mass index ≥20 kg/m²</td>
<td>822 (44.30)</td>
</tr>
<tr>
<td>Current alcohol use</td>
<td>770 (43.50)</td>
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<tr>
<td>Current tobacco use</td>
<td>304 (17.60)</td>
</tr>
<tr>
<td>Health insurance</td>
<td>1042 (60.10)</td>
</tr>
<tr>
<td>Education, less than high school</td>
<td>647 (34.80)</td>
</tr>
<tr>
<td>Income &lt;20000 US Dollars</td>
<td>900 (54.50)</td>
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</table>

#### Hispanic subgroup distribution

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>N (%)</th>
</tr>
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<tbody>
<tr>
<td>Dominican</td>
<td>326 (18.20)</td>
</tr>
<tr>
<td>Central American</td>
<td>176 (6.40)</td>
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<tr>
<td>Cuban American</td>
<td>356 (11.60)</td>
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<tr>
<td>Mexican American</td>
<td>458 (20.40)</td>
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<tr>
<td>Puerto Rican</td>
<td>348 (17.10)</td>
</tr>
<tr>
<td>South American</td>
<td>150 (6.20)</td>
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#### Echocardiographic parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean ± SEM</th>
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<tbody>
<tr>
<td>Left atrial volume index ≥34 mL/m²</td>
<td>122 (6.90)</td>
</tr>
<tr>
<td>Early diastolic mitral annular velocity (E′) &lt;8 cm/s</td>
<td>905 (52.50)</td>
</tr>
<tr>
<td>E/E′ ratio &gt;10</td>
<td>747 (41.0)</td>
</tr>
<tr>
<td>No LV diastolic dysfunction</td>
<td>812 (49.74)</td>
</tr>
<tr>
<td>LV diastolic dysfunction, Grade 1</td>
<td>230 (16.10)</td>
</tr>
<tr>
<td>LV diastolic dysfunction, Grade 2</td>
<td>556 (32.69)</td>
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<tr>
<td>LV diastolic dysfunction, Grade 3</td>
<td>31 (1.48)</td>
</tr>
<tr>
<td>LV mass, g</td>
<td>153±4.51</td>
</tr>
<tr>
<td>LV mass index, g/m²</td>
<td>41.5±0.34</td>
</tr>
<tr>
<td>Relative wall thickness</td>
<td>0.40±0.01</td>
</tr>
<tr>
<td>Ejection fraction, %</td>
<td>59.80±0.20</td>
</tr>
<tr>
<td>End-systolic volume, mL</td>
<td>33.80±0.37</td>
</tr>
<tr>
<td>End-diastolic volume, mL</td>
<td>83.50±0.70</td>
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*Data are presented as mean±SEM or N (%) using weighted row percentages; N’s presented are unweighted counts of total participants in the HCHS-SOL with respective characteristic.
multivariable models, only having prevalent CHD was independently inversely associated (odds ratio: 0.1; confidence intervals 0.1–0.3) with having subclinical or unrecognized cardiac dysfunction.

Hispanic/Latino Subpopulation and Cardiac Dysfunction

Individuals of Mexican background consistently had the lowest unadjusted prevalence of cardiac dysfunction, whereas the prevalence was higher among those of Central American backgrounds (Table 2). Among individuals of Central American backgrounds, more prevalent cardiac dysfunction was seen among younger age groups (Table 2). These differences were mostly driven by LVDD. In age-adjusted analysis, only participants of Central American background (odds ratio: 2.0; confidence intervals 1.2–3.2) had an increased odds of having LVDD compared with those of Mexican background. Differences among Central Americans persisted on multivariable models for LVDD (odds ratio: 1.7; confidence intervals 1.0–2.8). In additional models adjusted by study site, these differences were no longer significant. However, age-adjusted models stratified by site and Hispanic/Latino background revealed that LVDD prevalence among participants of Central American heritage did not significantly vary by site (P = 0.2).

Discussion

To our knowledge, ECHO-SOL is the largest community-based cohort to date representing diverse Hispanic/Latino groups that has been systematically examined with standardized echocardiography. No prior study has evaluated the prevalence of cardiac dysfunction, both systolic and diastolic, as well as the presence of subclinical or unrecognized cardiac dysfunction, in a community-based cohort of Hispanic/Latino adults representative of the 6 major Hispanic/Latino background groups. Previous population-based studies of US Hispanics/Latinos were smaller, single-site, and provided only limited information on LVSD, LVDD, and clinical HF. In ECHO-SOL, the prevalence of HF risk factors was high. Half of the participants were obese or hypertensive and two thirds being diabetic or prediabetic. Cardiac dysfunction was present in almost half of the cohort and due predominantly to diastolic dysfunction. This is important given the epidemic of HfPEF, which is projected to increase in the United States. Moreover, of all cardiac dysfunction, upwards of 95% was unrecognized or subclinical. Finally, there was a suggestion of differentially higher LVDD prevalence among certain Hispanic/Latino groups, in particular Central Americans, which may be more at risk.

Systolic Dysfunction and Diastolic Dysfunction

Prevalence of LVDD in the ECHO-SOL cohort was higher compared with previously published data for European cohorts: 11%25; 37%;30 In a community-based sample of 2042 non-Hispanic white residents of Olmsted County, Minnesota, Redfield et al31 reported an LVDD prevalence of 28%, clinical HF prevalence of 2.2%, and LVSD prevalence of 6% (EF ≤ 50%). In comparison, although the Olmsted cohort had study design similar to ECHO-SOL and also included participants aged ≥ 45 years, ECHO-SOL comprises exclusively of Hispanics/Latinos with greater proportion of women, higher mean BMI (28.4 versus 30.1), diabetes mellitus prevalence (4.5% versus 28.4%), and current tobacco use (17.6% versus 8.9%). Importantly, longitudinal follow-up of the Olmsted cohort showed that LVDD prevalence and severity worsened...
Clinical Heart Failure Among Hispanic/Latino Adults

Our analysis suggests that the prevalence of self-reported clinical HF in the Hispanic/Latino community is relatively low, despite the high prevalence of stage A and stage B HF. The majority of HF in our Hispanic/Latino study population seems to be stage B HF, which includes asymptomatic LVSD or asymptomatic LVDD. In predominantly non-Hispanic, white cohorts, the prevalence of asymptomatic LVSD and LVDD is estimated at 3% to 6%35 and 26%,36 respectively. Prior estimates of projected clinical HF prevalence in US Hispanics/Latinos have been low.37 However, these estimates are only based on Hispanics of one particular background group. When one examines a representative sample of all Hispanics/Latinos, such as in our study, the projected HF prevalence, particularly for future HFpEF, appears high. Furthermore, only approximately one third of Hispanics/Latinos with clinical cardiac dysfunction were on an angiotensin-converting enzyme inhibitor, β-blocker, or diuretic. This prevalence of cardiac medication use among those with clinical cardiac dysfunction is lower compared with previous publications38 and is even lower among ECHO-SOL participants with stage A and stage B HF. Because antecedent cardiac dysfunction (systolic or diastolic) is associated with increased incidence of clinical HF,4,27,39 the increased prevalence of subclinical or unrecognized functional abnormalities (stage B HF) coupled with a high burden of HF risk factors (stage A HF) makes the ECHO-SOL study population highly vulnerable to progression to...
clinically overt HF (stage C or stage D HF). Income, educational level or insurance status were not significantly associated with subclinical or unrecognized cardiac dysfunction, suggesting that the reasons for the high presence of stage B HF among Hispanics/Latinos goes beyond these variables and deserves further attention.

The available information regarding HF in Hispanics/Latinos from community-based cohorts is insufficient and conflicting. For example, national statistics from National Health and Nutrition Examination Survey shows HF prevalence as being the lowest in Hispanics/Latinos, followed by non-Hispanic Whites. However, others reported that HF incidence was greater in Hispanics/Latinos than in non-Hispanic Whites. Vivo et al reported on the prevalence of HFrEF (54%) and HFpEF (46%) in a registry of 6117 Hispanic/Latino patients hospitalized with HF. Hospitalized Hispanics/Latinos were younger, more obese, and more likely to have diabetes mellitus and hypertension compared with non-Hispanics/Latinos in the registry. Despite these differences, compared with non-Hispanic Whites, the prevalence of HFpEF (46% versus 55%) was lower and the prevalence of HFrEF was higher (54% versus 45%) in these Hispanic/Latino patients. Our study found that the prevalence of subclinical or unrecognized cardiac dysfunction was lower among those with clinical CHD. Thus, having the comorbid condition of clinical CHD increases the likelihood of having received attention of the healthcare system so that their cardiac dysfunction is less likely to be subclinical or unrecognized.

Hispanic/Latino Subpopulation Differences

We observed a differential prevalence of LVDD by Hispanic/Latino subpopulation where participants of Central American background had an almost 2-fold chance having LVDD compared with those of Mexican background. In additional
models adjusted by site, these differences were no longer significant. However, age-adjusted analysis stratified by site and Hispanic/Latino background group revealed that LVDD prevalence among Central Americans did not vary by site. Because the correlation between study site and Hispanic/Latino background group in ECHO-SOL is high, it becomes impossible to distinguish their effects separately. Although it is notable in our study that individuals of Central American background in Chicago and the Bronx were similar with respect to LVDD prevalence, it doesn’t help clearly distinguish whether the differentially higher LVDD prevalence in Central American background is because of site factors (such as environmental differences) or to intrinsic Hispanic/Latino background group differences (such as genetic ancestry).

**Comparisons With Other Populations in the Context of the Hispanic Paradox**

Hispanics in ECHO-SOL have higher prevalence of HF risk factors (diabetes mellitus, hypertension, and obesity) compared with non-Hispanic whites in the Multiethnic Study of Atherosclerosis (MESA), despite being younger. Non-Hispanic blacks in the MESA and the Atherosclerosis Risk In Communities (ARIC) study cohorts had similar prevalence of these risk factors when compared with ECHO-SOL Hispanics. Prevalence of asymptomatic LVSD in MESA was 1.7% among Whites, 2.7% among Non-Hispanic blacks, and 1.6% among Hispanics; however, MESA excluded prevalent CHD and clinical HF which were included in ECHO-SOL. When compared with non-Hispanic white cohorts of similar age, prevalence of LVSD in ECHO-SOL (3.6%) is lower than that in Framingham (5%), Heart of England Screening study (5.3%), and Mayo cohorts (6%), despite a higher level of HF risk factors among ECHO-SOL participants.

Using only transmitral Doppler in defining LVDD, the prevalence of asymptomatic LVDD was 25% among Non-Hispanic blacks in ARIC. ECHO-SOL Hispanics have a similarly high prevalence of HF risk factors as non-Hispanic blacks in ARIC, but a much higher prevalence of asymptomatic LVDD (47.1%). Prevalence of LVDD in population-based, non-Hispanic white cohorts, mean age was 53 to 65 years, has varied from 11% to 35%. In comparison, ECHO-SOL LVDD prevalence is higher, with a higher prevalence of HF risk factors, compared to non-Hispanic whites despite ECHO-SOL participants being younger or of similar age as seen in these published cohorts. This implies more HF risk among ECHO-SOL Hispanics despite a younger or similar age.

The Hispanic Paradox states that despite a high prevalence of risk factors, Hispanics seem to have a more favorable cardiovascular morbidity and mortality experience than non-Hispanic whites. Despite the increased prevalence of HF risk factors, ECHO-SOL Hispanics have a similar or lower prevalence of LVSD as non-Hispanic whites. These findings provide support for the Hispanic Paradox as it applies to the LVSD. However, LVDD prevalence is higher in ECHO-SOL with a higher prevalence of HF risk factors, despite a younger or similar age, which does not support the Hispanic paradox. The higher LVDD prevalence can be partly attributed to our comprehensive criteria for defining LVDD, which may be more sensitive than prior studies. Predominantly, this speaks to the complexity of the Hispanic Paradox and how it has been understudied in the context of cardiac dysfunction and HF.

**Strengths and Limitations**

Our study has several strengths. Our measures of LVDD are comprehensive, do not rely on a single component, and are inclusive of tissue Doppler assessment and left atrial volume index measurements as per the ASE and Redfield criteria. Previous LVDD criteria based solely on diastolic relaxation velocity has its own limitations. ASE has recommended that the best assessment of LVDD is when a combination of several diastology components are used. Our study tries to move closer to an ideal assessment by incorporating various components into our LVDD algorithm (Figure 1). A related strength is that LVDD could not be classified in <2% of our sample. This is a testament to our LVDD algorithm and the quality of our measures. We used modified Simpson’s biplane method, the ASE-recommended method for calculating LVEF, in all ECHO-SOL participants, whereas many prior

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**Table 4. Proportion of Subclinical or Unrecognized vs Clinical Cardiac Dysfunction Among All Participants**

<table>
<thead>
<tr>
<th>Cardiac dysfunction (LVSD and LVDD)</th>
<th>Subclinical</th>
<th>Clinical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Size (N)*</td>
<td>% (95% CI)</td>
<td>Sample Size (N)*</td>
</tr>
<tr>
<td>LVDD</td>
<td>838</td>
<td>96.1 (94.6–97.6)</td>
</tr>
<tr>
<td>EF&lt;50</td>
<td>55</td>
<td>92.7 (85.8–99.6)</td>
</tr>
<tr>
<td>LVDD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade 1</td>
<td>219</td>
<td>94.6 (90.5–98.7)</td>
</tr>
<tr>
<td>Grade 2</td>
<td>534</td>
<td>97.2 (95.7–98.7)</td>
</tr>
<tr>
<td>Grade 3</td>
<td>30</td>
<td>97.6 (92.8–100)</td>
</tr>
</tbody>
</table>

CI indicates confidence interval; EF, ejection fraction; HCHS-SOL, Hispanic Community Health Study/Study of Latinos; LVDD, left ventricular diastolic dysfunction; and LVSD, left ventricular systolic dysfunction.

*N's presented are unweighted counts of total participants in the HCHS-SOL with respective characteristic.

†Weighted row percentages.
studies calculated LVEF using the Teichholz method, an older M-mode method based on fractional shortening which is no longer recommended.

Some study limitations do exist. ECHO-SOL, by design, recruited specific Hispanic/Latino background groups by site because US Hispanic/Latino background groups have differential geographic immigration patterns. Second, echocardiographic studies were not performed simultaneously with other HCHS-SOL data. To alleviate this, all efforts were made to keep the time interval between baseline HCHS-SOL measurements and ECHO-SOL assessments as negligible as possible; additionally, key covariates (hypertension, diabetes mellitus, self-reported HF) were updated using the most recent HCHS-SOL annual follow-up assessment. Some participants could have had a reduced LVEF when they first self-reported HF, and the LVEF may have recovered by the time the echocardiography examination was performed, possibly limiting our HFpEF and HFrEF estimates. We obtained only the list of medications but not the actual indication for those medications. Various schemes have been used to define LVDD in prior studies, which make pure comparisons difficult. Finally, the diagnosis of clinical HF may be inaccurate because it is based on self-report and has not been validated by review of medical records.

Conclusions

The prevalence of cardiac dysfunction, especially LVDD, is high among the Hispanics/Latinos population. Even though the prevalence of HFpEF is higher than HFrEF among Hispanics/Latinos, overall cardiac dysfunction (LVDD or LVSD) is primarily subclinical or unrecognized. Our study substantiates the need for aggressive risk factor modification in this at-risk population as recommended in the guidelines to prevent further cardiac remodeling and progression to clinical HF.51

Acknowledgments

We acknowledge the investigators, the staff, and the participants of the Hispanic Community Health Study/Study of Latinos (HCHS-SOL) and the Echocardiographic Study of Latinos (ECHO-SOL) for their dedication and commitment to the success of this study. Investigators website: http://www.cscc.unc.edu/hchs/.

Sources of Funding

The Hispanic Community Health Study/Study of Latinos (HCHS-SOL) was performed as a collaborative study supported by contracts from the National Heart, Lung, and Blood Institute (NHLBI) to the University of North Carolina (N01-HC65233), University of Miami (N01-HC65234), Albert Einstein College of Medicine (N01-HC65235), Northwestern University (N01-HC65236), and San Diego State University (N01-HC65237). The following Institutes/Centers/Offices contribute to the HCHS-SOL through a transfer of funds to the NHLBI: National Institute on Minority Health and Health Disparities, National Institute on Deafness and Other Communication Disorders, National Institute of Dental and Craniofacial Research, National Institute of Diabetes and Digestive and Kidney Diseases, National Institute of Neurological Disorders and Stroke, NIH Institution-Office of Dietary Supplements. Echocardiographic Study of Latinos (ECHO-SOL) was supported by a grant from the National Heart, Lung, and Blood Institute (R01 HL104199, Epidemiological Determinants of Cardiac Structure and Function among Hispanics: Carlos J. Rodriguez, MD, MPH Principal Investigator).

Disclosures

None.

References


**CLINICAL PERSPECTIVE**

The Echocardiographic Study of Latinos (ECHO-SOL) is the largest study to date of U.S. Hispanic/Latino adults. This article presents the left ventricular (LV) dysfunction and heart failure (HF) data from this cohort. Our key findings indicate that the prevalence of HF risk factors (stage A HF) and LV diastolic dysfunction is high among Hispanics/Latinos. Prevalence of clinical HF is low, and most of the cardiac dysfunction is subclinical or unrecognized (stage B HF). Despite the increased prevalence of HF risk factors, ECHO-SOL Hispanics have a similar or lower prevalence of LV systolic dysfunction as non-Hispanic whites. These findings provide support for the Hispanic Paradox because it applies to the LV systolic dysfunction. However, LV diastolic dysfunction prevalence is higher in ECHO-SOL, with a higher prevalence of HF risk factors, despite a younger or similar age, which does not support the Hispanic Paradox. The findings from our study raise awareness of the increased prevalence of LV diastolic dysfunction and subclinical HF among Hispanics/Latinos. Our study substantiates the need for aggressive risk factor modification in this at-risk population.
Burden of Systolic and Diastolic Left Ventricular Dysfunction Among Hispanics in the United States: Insights From the Echocardiographic Study of Latinos

Circ Heart Fail. 2016;9:
doi: 10.1161/CIRCHEARTFAILURE.115.002733
Circulation: Heart Failure is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 1941-3289. Online ISSN: 1941-3297

The online version of this article, along with updated information and services, is located on the World Wide Web at:
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