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Major and Minor Electrocardiographic Abnormalities and their Association with Underlying Cardiovascular Disease and Risk Factors in Hispanics/Latinos (From the Hispanic Community Health Study/Study of Latinos [HCHS/SOL])

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Abstract

The association of ECG abnormalities with cardiovascular disease and risk factors has been extensively studied in Whites and African Americans. Comparable data have not been reported in Hispanics/Latinos. The Hispanic Community Health Study/Study of Latinos (HCHS/SOL) is a multicenter community based prospective cohort study of men and women of diverse backgrounds ages 18 to 74 years who self-identified as Hispanic/Latinos. Participants (N=16,415), enrolled between March 2008 and June 2011. We describe the prevalence of minor and major ECG abnormalities and examine their cross-sectional associations with cardiovascular disease and risk factors. The Minnesota code criteria were used to define minor and major abnormalities of the ECG. Prior cardiovascular disease and risk factors were based on data obtained at baseline examination. Significant differences in prevalent ECG findings were found between men and

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women. Major ECG abnormalities were present in 9.2 %(95% confidence interval [CI], 8.3–10.1) of men and 6.6% (95% CI, 5.8–7.3) of women (P<.0001). The odds of having major ECG abnormalities significantly increased with age, presence of 3 or more cardiovascular risk factors and prevalent cardiovascular disease, in both men and women. Significant differences in major ECG abnormalities were found among the varying groups; Puerto Ricans and Dominicans had more major abnormalities compared to Mexican men and women. In conclusion, a large cohort of Hispanic/Latino men and women, prevalence of major abnormalities were low yet strong associations of major ECG abnormalities with cardiovascular disease and risk factors were observed in both men and women.

Keywords

Electrocardiogram; Hispanic Community Health Study/Study of Latinos (SOL); cardiovascular risk factors

Introduction

The electrocardiogram (ECG) has been used as an inexpensive and widely available screening tool for the detection of the presence of cardiovascular disease (1, 2). The association of ECG abnormalities and underlying cardiovascular disease and the prognostic significance of the ECG have been extensively studied in Whites, and African Americans, and also reported in American Indians and Americans of Japanese descent but not in Hispanics (1–18). There is only limited information on ECG findings in the Hispanic population (19–23). Most studies compared specific ECG findings such as QRS voltage, ST height, and QT prolongation in racially diverse populations including Hispanics (20–23). The HCHS/SOL includes both men and women with a wide range of age, multiple countries of origin, and individuals with and without a history of heart disease and cardiovascular risk factors (24). The present study compares prevalent ECG findings between Hispanic/Latino men and women and evaluates the association of ECG findings with age and gender in the presence or absence of underlying heart disease and cardiovascular risk factors. Specifically, it examines the prevalence of minor and major baseline ECG abnormalities and their association with underlying cardiovascular disease and risk factors in a diverse group of Hispanic/Latino men and women.

Methods

The HCHS/SOL is a population-based cohort study designed to examine risk and protective factors for chronic diseases and to quantify morbidity and mortality prospectively. Details of the sampling methods and design have been published. (24,25,26). Briefly, between March 2008 and June 2011, 16 415 self-identified Hispanic/Latino persons of diverse background (Cubans, Dominicans, Mexicans, Puerto Ricans, Central Americans, and South Americans) aged 18 to 74 years were examined. Participants were recruited from randomly selected households in 4 US communities (Bronx, New York; Chicago, Illinois; Miami, Florida; San Diego, California). Households were selected using a stratified 2-stage area probability sample design. (25,26). Census block groups were randomly selected in the defined community areas of each field center, and households were randomly selected in each sampled block group. Households were screened for eligibility, and Hispanic/Latino persons aged 18 to 74 years were selected in each household agreeing to participate. Oversampling occurred at each stage, with block groups in areas of Hispanic/ Latino concentration, households associated with a Hispanic/Latino surname, and persons aged 45 to 74 years selected at higher rates than their counterparts. Sampling weights were generated to reflect the probabilities of selection at each stage. The study was approved by the institutional

review board at each participating institution; written informed consent was obtained from all participants (24,25,26).

The study design and study protocol and implementation have been previously published in detail (24,25,26). The baseline examination included medical history, medication use, family history, tobacco use, anthropometry, blood pressure, phlebotomy for laboratory studies and an ECG. Major CVD risk factors were defined based on current national guidelines.

Hypercholesterolemia and dyslipidemia were defined as total cholesterol 240 mg/dL or greater, LDL cholesterol 160 mg/dL or greater, or HDL cholesterol less than 40 mg/dL (for persons with and without diabetes) or receiving cholesterol-lowering medication (24). Hypertension was a systolic blood pressure 140 mm Hg or greater, diastolic blood pressure 90 mm Hg or greater or receiving antihypertensive medication (24). Diabetes mellitus was a fasting plasma glucose 126 mg/dL or greater, 2-hour post-load plasma glucose 200 mg/dL or greater, an HbA1c 6.5% or greater, or use of antihyperglycemic medications (24). Blood pressure and heart rate were measured by standard epidemiology procedures (5 minutes rest, 3 measures), using an automated blood pressure device [Omron model HEM-907 XL(Omron Healthcare Inc, Bannockburn, IL)] in a seated position. Smoking status was categorized as current smoker, past smoker, and never smoked. A positive family history of CVD was defined as answering yes to the question of having a first degree relative who had a heart attack at age < 55 years old. The presence of prior CVD was ascertained by answering yes to the questions of having had prior heart attack, coronary revascularization (CABG or PTCA/stent), rheumatic heart disease, heart failure or stroke/TIA. ECGs were obtained after an overnight fast and at least 2 hours after glucose load administration.

Resting standard, 10 second, simultaneous 12-lead ECG was digitally acquired using a GE MAC 1200 electrocardiograph (GE, Milwaukee, WI) at 10 mm/mV calibration and speed of 25 mm/s. ECG reading was performed centrally at the Epidemiological Cardiology Research Center (EPICARE), Wake Forest School of Medicine, Winston Salem, NC. All ECGs were initially inspected visually for technical errors and inadequate quality before being automatically processed using GE 12-SL Marquette Version 2001(GE, Milwaukee, WI). ECG abnormalities were classified and coded using the Minnesota ECG Classification (27). In addition to the individual ECG abnormalities, ECG tracings were classified as having a major or minor abnormality. Participants with only minor ECG abnormalities were classified as having “any minor abnormalities,” and participants with major ECG abnormalities with or without coexisting minor ECG abnormalities were classified as having “any major ECG abnormalities.” Major ECG abnormalities included: Major ventricular conduction defect; definite myocardial infarction (defined as the presence of major Q wave abnormalities); possible myocardial infarction (defined as the presence of minor Q-QS wave plus major ST-T abnormalities); major isolated ST-T abnormalities; left ventricular hypertrophy plus major ST-T abnormalities; major atrio-ventricular conduction abnormalities; major QT prolongation (QTI≥116% or JTI if QRS ≥120ms), pacemaker, and other major arrhythmias. Minor ECG abnormalities included: Minor isolated Q-QS waves; minor isolated ST-T abnormalities; high R waves; ST segment elevation; incomplete right bundle branch block; minor QT prolongation (QTI≥112% or JTI if QRS≥120 ms); short PR interval; left axis deviation; right axis deviation; frequent ventricular premature beats; and other minor abnormalities.

In addition to the Minnesota code defined ECG abnormalities, the automatically calculated global measurements of QT, PR, and QRS were also obtained. To calculate QTc interval from the raw QT and heart rate, recommendation of using linear models for adjustment for QTc from the American Heart Association (AHA), American College of Cardiology (ACC) and Heart Rhythm Society (HRS) for the Standardization and Interpretation of the

Electrocardiogram were followed(28). Therefore, the Framingham linear regression formula [QTc = QT +0.154 (1−{60/heart rate})] was used (29). QTc values of 460 ms or longer in women and 450 ms or longer in men were considered abnormal (i.e. prolonged QTc) (27).

The HCHS/SOL cohort was recruited with use of a stratified two-stage area probability sampling design in which participant's households were sampled from augmented residential mailing lists from pre-selected census block groups within each of the four regional field centers. The target population was the non-institutionalized Hispanic/Latino population ages 18–74 residing in the defined community areas. Trimmed, normalized sampling weights adjusted for non-response for enumerated but non-enrolled household members were derived and later calibrated to the 2010 US Census. Complete details of the sampling design have been reported in a technical report prepared by the study coordinating center. To account for the complex sampling design, all reported means and proportions are weighted. Model based means, proportions, odds ratios and p-values were obtained by fitting linear and logistic regression models for complex survey data. Standard errors were computed by using Taylor linearization method. All analysis were performed using SAS 9.3 survey specific procedures (SAS Institute, Cary, NC). Participants with missing ECG readings (N=203) and missing data on CVD risk factors (N=284); includes (9 participants > 74 years old, and 152, 49, 18, 71, 144 and 13 missing one or more of serum cholesterol, BMI, blood pressure, smoking, family history of CVD or diabetes status, respectively) and CVD status variables (N=116) were excluded from all analyses, leaving 15,812 participants in the analysis sample. To preserve the study design and ensure that the standard errors are computed correctly, the exclusions were made by using the DOMAIN statement in SAS survey procedures. Weighted prevalence percents have been age standardized to the year 2000 Census to make them more comparable to NHANES data (30).

Results

Baseline characteristics of the study group are shown in Table 1. At baseline examination, men had higher prevalence of history of hypercholesterolemia, being current smokers, having history of heart attack and coronary revascularization; they had higher systolic and diastolic blood pressure. Women were older, more obese, and had faster heart rates.

The prevalent age adjusted major and minor ECG abnormalities comparing men and women are shown in Table 2. Major ECG abnormalities were more frequent in men. The three more common major ECG abnormalities in men were major Q waves (MC 1.1, 1.2), ventricular conduction defects (MC 7.1, 7.2, 7.4, 7.8) and major isolated ST-T abnormalities (MC 4.1 o 4.2 or 5.1 or 5.2). In women these ECG abnormalities had also the highest prevalence but compared to men the prevalence of major Q waves (MC 1.1, 1.2), and ventricular conduction defects (MC 7.1, 7.2, 7.4, 7.8) were significantly lower and major isolated ST-T abnormalities (MC 4.1 o 4.2 or 5.1 or 5.2) were higher. There were significant differences in the prevalence of certain minor ECG abnormalities. Men had a higher prevalence of minor isolated Q waves (MC 1.3), tall R waves (MC 3.1, 3.3, 3.4), ST elevation (MC 9.2), incomplete right bundle branch block (MC 7.3), left axis deviation (MC 2.1), frequent VPB (8.1.2, 8.1.3) and sinus bradycardia (MC 8.8). Women had a higher prevalence of minor isolated ST-T abnormalities (MC 4.3, 4.4, 5.3, 5.4), low QRS voltage (MC 9.1) and minor QT prolongation index.

The comparison of the prevalent ECG findings and major and minor ECG abnormalities by CVD risk status or disease in men and women is shown in Tables 3 and 4. There was a significant trend, in both men and women, for increasing heart rate, QRS and QTc duration and QT prolongation index as the number of CVD risk factors increased or in the presence of prevalent CVD, compared to those with no CVD risk factors. Examining major ECG

abnormalities in men there was a significant trend for increasing prevalence of major Q waves (MC 1.1, 1.2), major isolated ST-T abnormalities (MC 4.1 o 4.2 or 5.1 or 5.2), left ventricular hypertrophy plus major ST-T abnormality {MC 3.1+ (4.1 or 4.2 or 5.1 or 5.2)} and ventricular conduction defects (MC 7.1, 7.2, 7.4, 7.8) with the number of CVD risk factors and prevalent CVD. The prevalence of any major ECG abnormality was 6.22% in men without CVD risk factors or disease and 28.44% in those with prevalent CVD. In women the prevalence of any major ECG abnormality was 5.40% in those without CVD risk factors or disease and 16.71% in those with prevalent CVD. In women, significant trends were observed for the presence of major Q waves (MC 1.1, 1.2), major isolated ST-T abnormalities (MC 4.1 o 4.2 or 5.1 or 5.2), left ventricular hypertrophy plus major ST-T abnormality {MC 3.1+ (4.1 or 4.2 or 5.1 or 5.2)} and major QT prolongation index (QTI ≥ 116) with the number of CVD risk factors and prevalent CVD. Examining minor ECG abnormalities in men there was a significant trend for higher prevalence of minor isolated ST-T abnormalities (MC 4.3, 4.4, 5.3, 5.4) with higher risk factor burden. An inverse trend for ST elevation (MC 9.2) and sinus bradycardia was present with greater risk factor burden. ST elevation (MC 9.2) was observed in 15.24% of men without CVD risk factors or disease; these were most commonly seen in the inferior leads. In women significant trends were observed for the presence of minor isolated Q waves (MC 1.3), minor isolated ST-T abnormalities (MC 4.3, 4.4, 5.3, 5.4), and tall R waves (MC 3.1, 3.3, 3.4)across the risk factor burden groups. ST elevation in women showed no reverse trend and the prevalence was low (0.78%) in those without CVD risk factors or disease.

Cross-sectional associations of major ECG abnormalities with CVD risk factors, prevalent CVD, and ethnic background are shown in figure 1. The odds of having major ECG abnormalities was significantly increased in men with age (1 SD delta), history of hypertension, diabetes, current smoker status, heart rate(1 SD delta), systolic and diastolic blood pressure(1 SD delta), 3 or three or more risk factors or prevalent cardiovascular disease. Similar significant associations were found in women except for current smoking status, diastolic blood pressure and three or more CVD risk factors. The odds ratios of having major ECG abnormalities increased in all age groups (years, 35–54, 55–64 and 65 or greater) of both men and women compared to the reference group (years 18–34), even when adjusted for CAD risk factors. The adjusted odds ratio for men age 65 or more for having major ECG abnormalities was 5.6 compared to the reference group and it was 3.5 for women.

The analysis of the effect of age on major ECG abnormalities is shown in figure 2. The population weighted prevalence (%) of major ECG abnormalities was higher at older ages in both men and women. The prevalence of major ECG abnormalities increased from 5.7% in the second decade (18–29 years) to 32.4% in the seventh decade (70–74 years) in men and 4.7% to 14.9% for the corresponding age groups for women. Interestingly, the first significant increase occurred in the fifth decade when the prevalence of major ECG abnormalities doubled.

The HCHS/SOL included participants from Mexican, Cuban, Puerto Rican, Dominican, Central American and South American background. In order to examine if significant differences existed in the odds of having major ECG abnormalities among these groups we designated the Mexican group as reference because they had the largest number of participant in the study. Significant differences in the odds of having major ECG abnormalities were found by ethnic background. The odds of having major ECG abnormalities were significantly higher in Dominicans and Puerto Ricans men and women compared to Mexicans (Figure 1).

Discussion

The existing data on ECG findings are derived from largely white population (1, 3–5, 7,8, 10, 11, 14). However, a number of studies have focused on groups with different racial backgrounds. The Strong Heart study examined ECG abnormalities among American Indians (17). The Honolulu Heart Program examined the predictive value of ECG in men of Japanese descent (18). The Evans County and Charleston Heart studies showed that African-Americans have a higher prevalence of ECG abnormalities and less coronary heart disease than White men (6,9). Differences in ECG abnormalities were found in the biracial population of the ARIC, CARDIA and REGARDS studies (12,13,15,16). African American men and women have higher prevalence of ECG abnormalities than Whites (6,9,12,15,16). Other studies reported differences in specific ECG measures such as, QT and QT subintervals, QRS amplitudes, left ventricular hypertrophy and in ST heights in ethnically diverse population (20–23). The largest and most comprehensive study on the value of the ECG in Hispanics was reported from the Palo Alto Veterans Affair (PAVAS) Health Care System (19). The study included 2,625 Hispanic and 41,546 non-Hispanic patients, with >90% of them being men. There were fewer CVD deaths in the Hispanic group compared to the non-Hispanics. There were also significant differences in ECG abnormalities between the two groups with the Hispanic showing fewer ECG abnormalities. The study did not report on the major and minor ECG abnormalities but the more frequent abnormalities included pathologic Q waves (10.6%) and left axis deviation (9.3%). The analysis was not adjusted for age, or the presence of underlying heart disease and risk factors.

There has been no large community based prospective cohort study examining the prevalence of ECG abnormalities in Hispanic/Latinos. This report on a community based prospective cohort study of large number of Hispanic/Latino men and women provides prevalence estimates of minor and major baseline ECG abnormalities and their associations with underlying cardiovascular disease and risk factors. It also evaluates the effect of age and gender on ECG characteristics. Findings are presented separately for men and women. Data are also weighted to reflect the non-institutional Hispanic/Latino adults residing in the defined community areas of recruitment in each of the four field centers as well as to facilitate subsequent comparison between ethnic groups.

Significant differences in ECG findings between Hispanic/Latino men and women were found. The prevalence of any major ECG abnormality was 6.22% in men without CVD risk factors or disease and 28.44% in those with prevalent CVD. In women the prevalence of any major ECG abnormality was 5.40% in those without CVD risk factors or disease and 16.71% in those with prevalent CVD. Our results confirm the findings of previous studies not including Hispanic/Latino participants showing a higher prevalence of major ECG abnormalities in men compared to women (1). The more common major abnormalities in men were major Q waves in 2.76 %, and major isolated ST-T abnormalities in 3.04%, while in women these were 1.36% and 3.62%, respectively. The more common minor abnormalities in men were ST segment elevation in 10.18% and, minor isolated Q/QS waves in 7.71%, while in women these were 1.41% and 5.75%, respectively. We confirmed previous observations on the association of ST segment elevation with male gender and younger age (1).

The direct association between age and prevalence of major ECG abnormalities was also confirmed by our study (1). The odds ratio of having major ECG abnormalities significantly increased with age, presence of 3 or more cardiovascular risk factors and prevalent cardiovascular disease, in both men and women. The population weighted prevalence of major ECG abnormalities increased from 5.7% in the second decade (18–29 years) to 32.4%

in the seventh decade (70–74 years) in men and 4.7% to 14.9% for the corresponding age groups for women.

An interesting finding of our study is the observation that major ECG abnormalities are significantly more likely to be found in both men and women of Puerto Rican and Dominican background compared to Mexicans. This is consistent with the findings of the previous publication on CVD risk factors in Hispanic/Latino individuals, showing that participants with Puerto Rican background have higher prevalence of adverse CVD risk profiles (24). We hypothesize that the higher prevalence of major ECG abnormalities in Dominicans is related to a higher prevalence of participants of African descent. It has been shown that African -Americans have a higher prevalence of ECG abnormalities than non-Hispanic Whites (6,9,12,15,16). Further studies are needed to confirm these findings and understand the etiology and mechanism underlying them.

A methodological limitation of the study is that the presence of underlying CVD and some of the risk factors are self-reported and not based on review of medical records. A significant shortcoming of the present report is the absence of follow-up data at the present time to evaluate the prognostic significance of the ECG findings. The major strength includes large cohort study, diverse population of Hispanic/Latinos, uniform measurements, interpretation and reporting of the ECG data by using the Minnesota code classification and computerized ECG from a central reading center (EPICARE).

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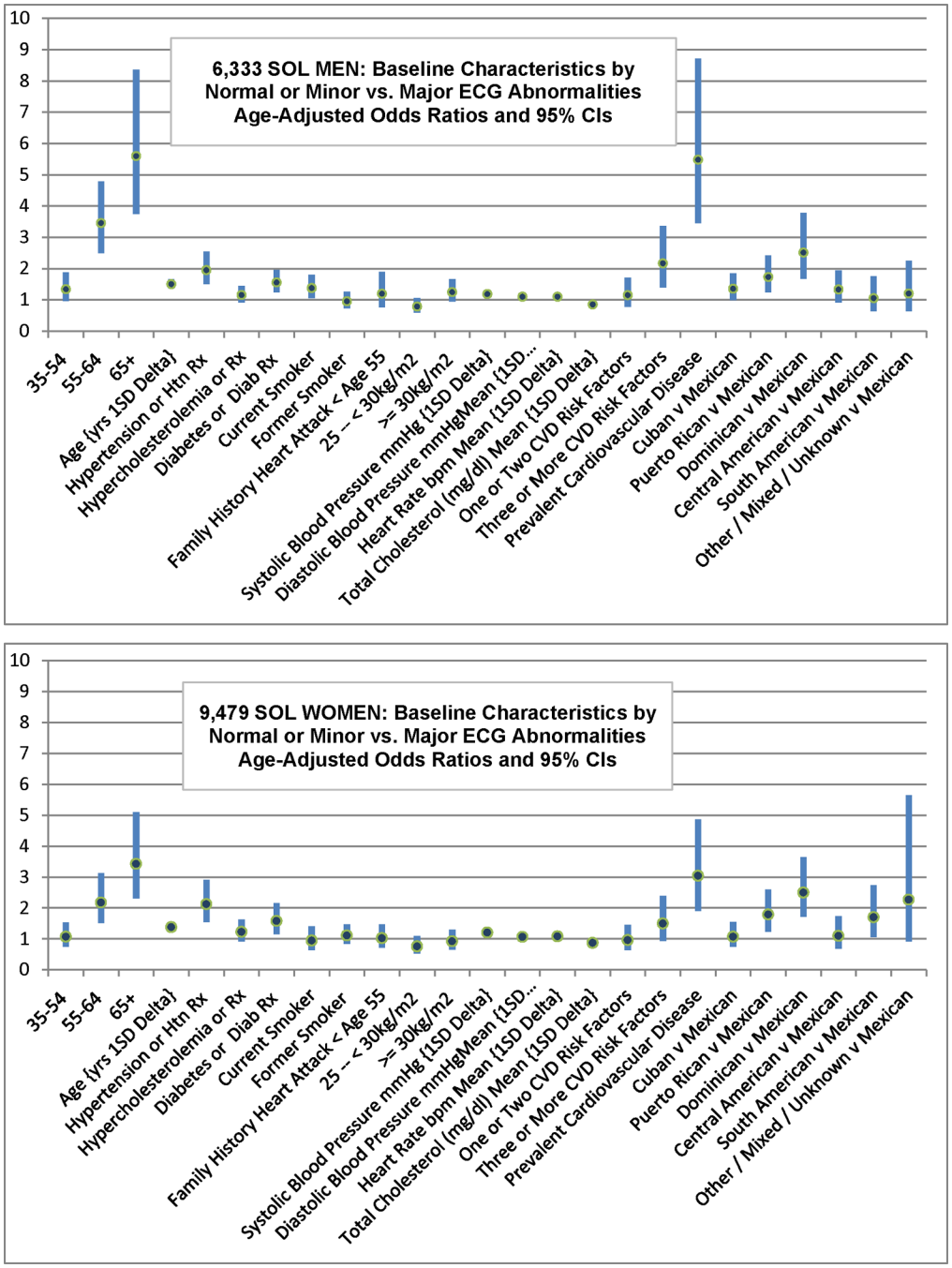

Figure 1.

Baseline characteristic by normal or minor vs. major ECG abnormalities.

Figure 1a. 6,333 HCHS/SOL male participants. Figure 1b. 9,479 HCHS/SOL female participants. Age-adjusted odds ratios and 95 % confidence intervals. Ethnic background odd ratios are further adjusted for hypertension (or medication), hyperlipidemia (or medication), obesity, diabetes (or medication) & current smoking. CVD = Cardiovascular Disease; Diab= Diabetes; Htn = hypertension; Rx = medication.

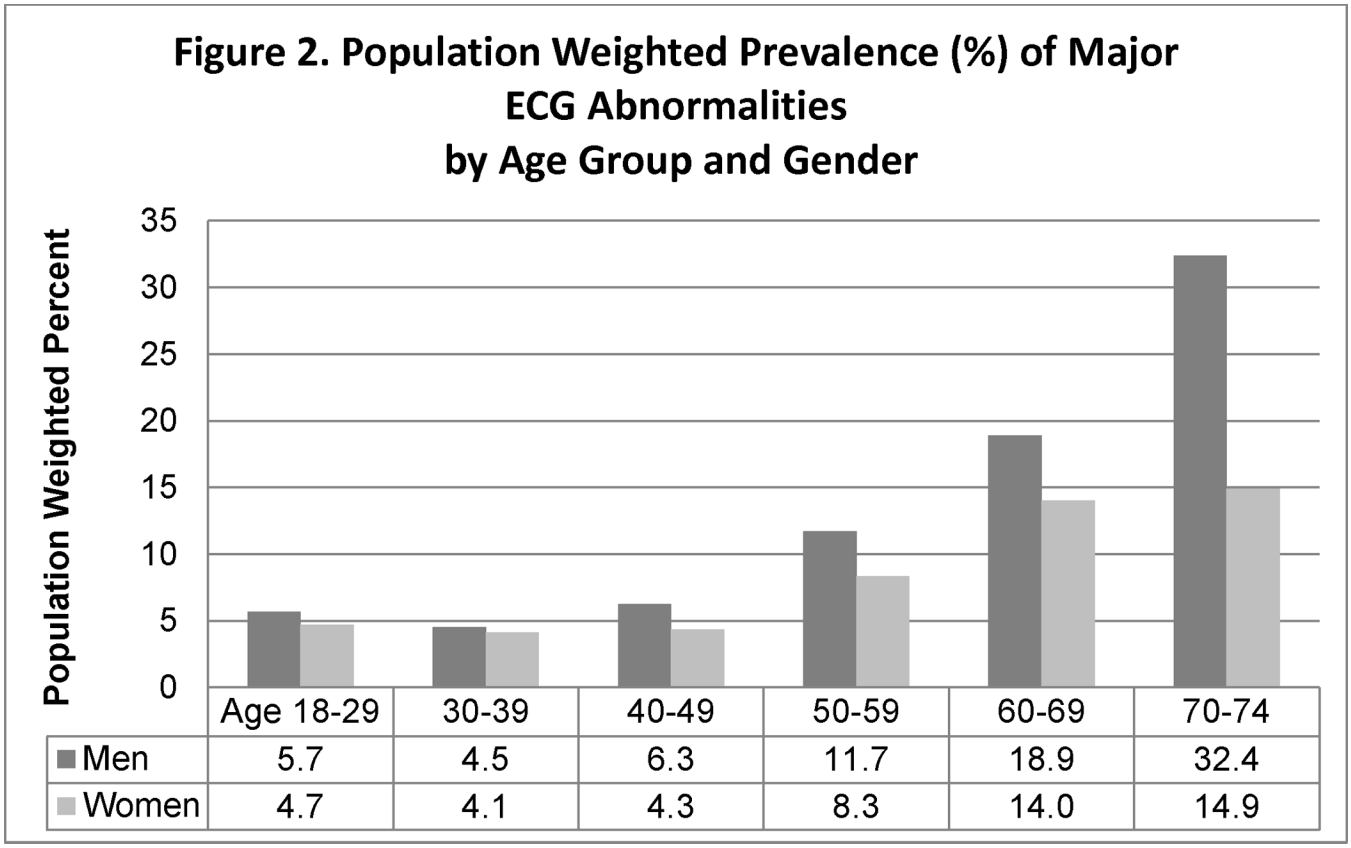

Figure 2.
Population weighted prevalence (%) of major ECG abnormalities by age group and gender. Data are presented in percentages for six decades of age for both men and women.

Table 1

Baseline Characteristics of 15,812 HCHS/SOL Participants[a]

Characteristic	Men (N=6,333)	Women (N=9,479)	p-value[b]
Age (years)			
18–34	40.4%	36.7%	0.0006
35–54	40.3%	40.5%	0.8471
55–64	11.8%	13.4%	0.0023
65+	7.5%	9.3%	0.0036
Age (years), mean (SD)	40.23 (0.31)	41.80 (0.28)	<.0001
Hypertension or antihypertensive medication,	21.9%	21.5%	0.6698
Hypercholesterolemia or lipid lowering medications,	50.1%	35.0%	<.0001
Diabetes mellitus or diabetes medication,	13.7%	15.5%	0.0196
Smoking status			
Current	26.8%	16.4%	<.0001
Former	21.8%	12.8%	<.0001
Never	51.4%	70.8%	<.0001
Family history heart attack < Age 55	6.8%	8.3%	0.0109
Body mass index (kg/m^2)			
< 25	22.7%	23.6%	0.4271
25–< 30	40.8%	33.9%	<.0001
≥ 30	36.5%	42.5%	<.0001
Systolic blood pressure (mmHg), mean (SD)	123.40 (0.28)	116.70 (0.32)	<.0001
Diastolic blood pressure (mmHg), mean (SD)	73.53 (0.23)	70.96 (0.21)	<.0001
Heart rate (bpm), mean (SD)	61.85 (0.26)	63.77 (0.17)	<.0001
Total cholesterol (mg/dl), mean (SD)	194.48 (0.81)	194.27 (0.68)	0.8339
Prior cardiovascular disease			
Prior myocardial infarction	2.6%	1.4%	0.0001
Revascularization, (CABG, PCI, Stent)	1.7%	1.0%	0.0003
Prior Stroke / TIA	2.3%	2.2%	0.7178
Rheumatic heart disease	0.3%	0.7%	0.0323
Heart failure	1.6%	2.0%	0.1607
Mexican	36.9%	38.5%	0.1318
Cuban	22.1%	18.5%	<.0001
Puerto Rican	16.5%	14.7%	0.0249
Dominican	8.2%	11.7%	<.0001
Central American	7.4%	7.5%	0.8061
South American	4.7%	5.1%	0.2487
Other / Mixed / Unknown	4.3%	4.1%	0.6378

Abbreviations: BMI, body mass index; CABG, coronary artery bypass grafting; PCI, percutaneous coronary intervention; TIA, transient ischemic attack.

[a] All values (except number of persons in headings) weighted for study design and non-response with use of SURVEY versions of SAS procedures. Percents represent column percents from the corresponding 2x2 table with only participants with the indicated condition or trait displayed.

[b] P-values from chi-square for 2x2 cross tabulation for discrete variables or t-test for continuous variables.

Table 2

Prevalent Electrocardiographic Abnormalities in 15,812 HCHS/SOL Participants (Age Standardized)[a]

Abnormality	Men (n=6,333)	Women (n=9,479)	p-value[b]
Major Minnesota Code Abnormalities	**Percent (95% CI)**		
Major Q wave abnormalities (MC 1.1, 1.2)	2.76 (2.21–3.31)	1.36 (0.94–1.78)	<.0001
Minor Q wave plus major ST-T abnormalities (MC 1.3 + (4.1 or 4.2 or 5.1 or 5.2))	0.29 (0.17–0.42)	0.37 (0.19–0.55)	0.4862
Major isolated ST-T abnormalities (MC 4.1 or 4.2 or 5.1 or 5.2)	3.04 (2.53–3.56)	3.62 (3.10–4.14)	0.1171
Left ventricular hypertrophy w/ major ST-T abn (MC 3.1 or 3.4) + (4.1 or 4.2 or 5.1 or 5.2)	0.53 (0.31–0.76)	0.21 (0.12–0.31)	0.0138
Atrial fibrillation/flutter (MC 8.3)	0.30 (0.11–0.49)	0.04 (0.00–0.08[c])	0.0095
Ventricular conduction defects (MC 7.1, 7.2, 7.4, 7.8)	3.39 (2.88–3.90)	1.36 (1.01–1.71)	<.0001
Complete/intermittent LBBB (MC 7.1)	0.21 (0.10–0.32)	0.26 (0.12–0.39)	0.5955
Complete/intermittent RBBB (MC 7.2)	1.53 (1.20–1.85)	0.71 (0.45–0.97)	<.0001
Nonspecific IVCD (MC 7.4)	1.43 (1.04–1.81)	0.37 (0.16–0.57)	<.0001
Complete/intermittent RBBB with left anterior hemiblock (MC 7.8)	0.23 (0.06–0.39)	0.03 (−0.00–0.05[c])	0.0214
Major AV conduction abnormalities (MC 6.1, 6.2)	0.00 (−0.00–0.01[c])	0.00 (−0.00–0.01[c])	0.8995
WPW (MC 6.4)	0.06 (−0.02–0.13[c])	0.03 (−0.00–0.05[c])	0.4198
Major QT prolongation index (QTI ≥ 116 or JTI if QRS ≥ 120)	0.58 (0.31–0.84)	0.54 (0.36–0.73)	0.8337
Other major arrhythmias (MC 8.2, 8.4.2 or 8.4.1 w/ HR ≥ 140)	0	0	--
Artificial pacemaker (MC 6.8)	0.22 (0.07–0.37)	0.02 (−0.01–0.05[c])	0.0132
Any major ECG abnormality	9.20 (8.34–10.06)	6.55 (5.78–7.32)	<.0001
Minor Minnesota Code abnormalities			
Minor isolated Q waves (MC 1.3)	7.71 (6.85–8.57)	5.75 (4.90–6.61)	0.0009
Minor isolated ST, T abnormalities (MC 4.3, 4.4, 5.3, 5.4)	5.38 (4.66–6.11)	6.65 (5.80–7.51)	0.0253
Tall R waves left (MC 3.1, 3.3, 3.4)	7.15 (6.21–8.08)	3.02 (2.43–3.62)	<.0001
Low voltage (MC 9.1)	0.82 (0.54–1.10)	2.49 (2.10–2.88)	<.0001
Tall R wave right (MC 3.2)	0.46 (0.18–0.74)	0.02 (−0.01–0.04[c])	0.0024
ST elevation (MC 9.2)	10.18 (9.14–11.21)	1.41 (1.05–1.78)	<.0001
ST elevation (MC 9.2): Anterior leads	3.10 (2.49–3.71)	0.72 (0.42–1.01)	<.0001
ST elevation (MC 9.2): Lateral leads	1.63 (1.19–2.07)	0.55 (0.32–0.79)	<.0001
ST elevation (MC 9.2): Inferior leads	7.85 (6.93–8.77)	0.54 (0.33–0.75)	<.0001
Incomplete RBBB (MC 7.3)	2.63 (1.95–3.30)	1.82 (1.39–2.25)	0.0411
Left axis deviation (MC 2.1)	2.30 (1.82–2.78)	1.35 (0.82–1.88)	0.0109
Right axis deviation (MC 2.2)	0.08 (0.02–0.14)	0.00 (−0.00–0.01[c])	0.0113
Minor QT prolongation index (QTI ≥ 112 < 116 or JTI if QRS ≥ 120)	0.66 (0.46–0.87)	2.55 (1.92–3.18)	<.0001
Frequent VPB (MC 8.1.2, 8.1.3, 8.1.5)	0.98 (0.64–1.31)	0.53 (0.32–0.74)	0.0308
Sinus bradycardia (MC 8.8)	8.50 (7.47–9.53)	4.20 (3.65–4.74)	<.0001
Other minor abnormalities (MC 6.3, 6.5, 8.1.1, 8.1.4, 8.4.1, 8.7, 9.3)	6.70 (5.82–7.58)	6.48 (5.76–7.21)	0.7091

Abbreviations: ECG, electrocardiogram; LBBB, left bundle branch block; RBBB, right bundle branch block; IVCD, intraventricular conduction delay; AV, atrio-ventricular; WPW, Wolff-Parkinson-White; VPB, ventricular premature beats.

[a] All values (except number of persons in headings) weighted for study design and non-response with use of SURVEY versions of SAS procedures and Age Standardized to the 2000 US Population.

[b] Age-adjusted p-value for difference between men and women from SAS SURVEYREG procedure.

[c] Cell contains fewer than five observations.

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Table 3

Electrocardiographic Findings and Abnormalities by Cardiovascular Disease Risk Factor Status in 6,333 HCHS/SOL Male Participants[a]

ECG Findings	No CVD Risk Factors	1 or 2 CVD Risk Factors[b]	3+ CVD Risk Factors[b]	Prevalent CVD[b]	p-Trend[c]
Heart rate (bpm)	59.1	61.7 ***	65.7 ***	63.2 **	<.0001
PR duration (ms)	160.2	159.2	159.5	160.2	0.8126
QRS duration (ms)	96.6	96.0	97.8	103.6 ***	<.0001
QT duration (ms)	409.3	408.2	404.4 **	415.5	0.9791
QTc duration (ms)	395.8	409.2 ***	427.4 ***	419.7 ***	<.0001
QT index (calculated)[d]	98.66	99.99 ***	101.12 ***	101.23 ***	<.0001
Major Minnesota Code Abnormalities					
Major Q wave abnormalities (MC 1.1, 1.2)	1.57	1.80	3.63	12.04 ***	<.0001
Minor Q wave plus major ST-T abnormalities (MC 1.3 + (4.1 or 4.2 or 5.1 or 5.2)	0.14	0.29	0.40	0.52	0.1005
Major isolated ST-T abnormalities (MC 4.1 or 4.2 or 5.1 or 5.2)	2.37	2.22	3.35	10.11 ***	0.0001
Left ventricular hypertrophy w/ major ST-T abn (MC 3.1 or 3.4) + (4.1 or 4.2 or 5.1 or 5.2)	0.24	0.42	0.66	2.03 [a]	0.0205
Atrial fibrillation/flutter (MC 8.3)	0.24	0.21	0.25	0.99	0.2615
Ventricular conduction defects (MC 7.1, 7.2, 7.4, 7.8)	2.36	2.46	4.51 *	7.98 ***	<.0001
Complete/intermittent LBBB (MC 7.1)	0.18	0.11	0.45	0.50	0.1046
Complete/intermittent RBBB (MC 7.2)	1.27	0.98	1.90	4.09 *	0.0046
Nonspecific IVCD (MC 7.4)	0.75	1.22	1.78	3.40 **	0.0035
Complete/intermittent RBBB with left anterior hemiblock (MC 7.8)	0.18	0.15	0.38	−0.01	0.8055
Major AV conduction abnormalities (MC 6.1,6.2)	0.01	0.01	−0.00	−0.01	0.3194
WPW (MC 6.4)	0.01	0.10	−0.01	−0.02	0.4896
Major QT prolongation index (QTI ≥ 116 or JTI if QRS ≥120)[d]	0.25	0.45 *	0.52	2.08	0.0834
Other major arrhythmias (MC 8.2, 8.4.2 or 8.4.1 w/ HR ≥ 140)	0.00	0.00	0.00	0.00	.
Artificial pacemaker (MC 6.8)	0.05	0.02	0.05	2.32 *	0.0109
Any major ECG abnormality	6.22	6.54	11.96 ***	28.44 ***	<.0001
Minor Minnesota Code Abnormalities					
Minor isolated Q waves (MC 1.3)	8.35	6.69	9.65	9.39	0.3366
Minor isolated ST, T abnormalities (MC 4.3, 4.4, 5.3, 5.4)	4.87	4.10	5.62	15.13 ***	<.0001
Tall R waves left (MC 3.1, 3.3, 3.4)	6.67	6.81	8.84	9.68	0.0839

ECG Findings	No CVD Risk Factors	1 or 2 CVD Risk Factors[b]	3+ CVD Risk Factors[b]	Prevalent CVD[b]	p-Trend[c]
Low voltage (MC 9.1)	0.67	0.83	0.90	0.50	0.8968
Tall R wave right (MC 3.2)	1.29	0.27	0.29	0.45	0.0967
ST elevation (MC 9.2)	15.24	9.50 **	8.59 **	10.88	0.0091
ST elevation (MC 9.2): Anterior leads	5.52	2.78 *	2.26 **	3.32	0.0421
ST elevation (MC 9.2): Lateral leads	2.66	1.56	1.06 *	0.94 *	0.0295
ST elevation (MC 9.2): Inferior leads	11.61	7.38 **	6.66 **	7.87 *	0.0089
Incomplete RBBB (MC 7.3)	2.82	2.04	3.84	3.21	0.4517
Left axis deviation (MC 2.1)	2.77	1.81	2.96	2.84	0.7101
Right axis deviation (MC 2.2)	0.08	0.04	0.11	0.27	0.5364
Minor QT prolongation index (QTI ≥ 112 < 116 or JTI if QRS ≥ 120)[d]	0.51	0.62	0.84	1.06	0.2211
Frequent VPB 9 (MC 8.1.2, 8.1.3, 8.1.5)	0.92	0.74	0.78	3.09	0.1909
Sinus bradycardia (MC 8.8)	12.86	8.17 **	4.24 ***	9.86	0.0218
Other minor abnormalities (MC 6.3,6.5,8.1.1,8.1.4,8.4.1,8.7,9.3.)	6.51	6.87	5.47	6.60	0.6341

Abbreviations: ECG, electrocardiogram; CVD, cardiovascular disease; LBBB, left bundle branch block; RBBB, right bundle branch block; IVCD, intraventricular conduction delay; VPB, ventricular premature beats.

[a] All values (except number of persons in headings) weighted for study design and non-response with use of SURVEY versions of SAS procedures. Numbers are age-adjusted means for continuous variables or prevalences (percents) of the indicated abnormality within each of the CVD risk factor groups.

[b] *, **, *** for 0.05, 0.01, 0.001 significance level for comparison with No CVD Risk Group.

[c] Age-adjusted p-value for trend from ordinal risk factor group variable in PROC SURVEYREG model.

[d] QT Index = (QT Duration/656) * (Heart Rate + 100) unless QRS duration > 120: then QT Index = ((QT dur - QRS dur) / 518) * (Heart Rate + 100).

Table 4

Electrocardiographic Findings and Abnormalities by Cardiovascular Disease Risk Factor Status in 9,479 HCHS/SOL Female Participants[a]

ECG Findings	No CVD Risk Factors	1 or 2 CVD Risk Factors[b]	3+CVD Risk Factors[b]	Prevalent CVD[b]	p-Trend[c]
Heart rate (bpm)	62.2	63.7 ***	67.3 ***	65.3 ***	<.0001
PR duration (ms)	152.4	153.4	154.0	154.5	0.0698
QRS duration (ms)	87.2	88.4 **	90.0 ***	90.5 ***	<.0001
QT duration (ms)	418.8	419.6	414.0 ***	419.3	0.1232
QTc duration (ms)	426.1	434.5 ***	448.5 ***	441.0 ***	<.0001
QT index (calculated)[d]	103.09	104.28 ***	105.04 ***	105.02 ***	<.0001
Major Minnesota Code Abnormalities					
Major Q wave abnormalities (MC 1.1, 1.2)	0.44	1.10	3.15	4.62 ***	0.0004
Minor Q wave plus major ST-T abnormalities (MC 1.3 + (4.1 or 4.2 or 5.1 or 5.2)	0.20	0.19	0.59	1.98	0.0311
Major isolated ST-T abnormalities (MC 4.1 or 4.2 or 5.1 or 5.2)	3.47	2.89	3.84	9.97 ***	0.0019
Left ventricular hypertrophy w/ major ST-T abn (MC 3.1 or 3.4) + (4.1 or 4.2 or 5.1 or 5.2)	0.09	0.07	0.50	1.38 *	0.0022
Atrial fibrillation/flutter (MC 8.3)	0.02	0.03	0.10	0.15	0.2003
Ventricular conduction defects (MC 7.1, 7.2, 7.4, 7.8)	1.43	1.07	1.69	1.64	0.7409
Complete/intermittent LBBB (MC 7.1)	0.29	0.27	0.07	0.14	0.4879
Complete/intermittent RBBB (MC 7.2)	0.96	0.44	0.89	0.92	0.7967
Nonspecific IVCD (MC 7.4)	0.16	0.35	0.68	0.48	0.0509
Complete/intermittent RBBB with left anterior hemiblock (MC 7.8)	0.01	0.01	0.05	0.09	0.3363
Major AV conduction abnormalities (MC 6.1, 6.2)	0.00	−0.00	−0.00	0.08	0.3180
WPW (MC 6.4)	0.01	0.04	0.01	−0.01	0.8285
Major QT prolongation index (QTI ≥ 116 or JTI if QRS ≥120)[d]	0.21	0.49 *	0.55	2.24 *	0.0041
Other major arrhythmias (MC 8.2, 8.4.2 or 8.4.1 w/ HR ≥ 140)	0.00	0.00	0.00	0.00	.
Artificial pacemaker (MC 6.8)	0.00	−0.00	−0.01	0.40	0.1599
Any major ECG abnormality	5.40	5.23	9.04 *	16.71 ***	<.0001
Minor Minnesota Code Abnormalities					
Minor isolated Q waves (MC 1.3)	3.10	6.71 ***	7.75 ***	6.30 *	0.0003
Minor isolated ST, T abnormalities (MC 4.3, 4.4, 5.3, 5.4)	4.60	6.07	9.34 ***	11.37 **	<.0001
Tall R waves left (MC 3.1, 3.3, 3.4)	1.42	2.85 **	5.99 **	5.47 *	0.0002

ECG Findings	No CVD Risk Factors	1 or 2 CVD Risk Factors[b]	3+CVD Risk Factors[b]	Prevalent CVD[b]	p-Trend[c]
Low voltage (MC 9.1)	2.37	2.51	1.90	3.62	0.6496
Tall R wave right (MC 3.2)	0.04	0.00	0.00	0.12	0.7051
ST elevation (MC 9.2)	0.78	1.75 *	1.33	2.43	0.0661
ST elevation (MC 9.2): Anterior leads	0.50	0.91	0.49	1.47	0.3335
ST elevation (MC 9.2): Lateral leads	0.15	0.84 *	0.31	0.72	0.1550
ST elevation (MC 9.2): Inferior leads	0.35	0.55	1.01	0.53	0.1745
Incomplete RBBB (MC 7.3)	1.96	1.58	1.98	3.34	0.5479
Left axis deviation (MC 2.1)	1.16	1.16	2.36	0.18	0.8717
Right axis deviation (MC 2.2)	0.00	0.00	−0.00	−0.00	0.3204
Minor QT prolongation index (QTI ≥ 112 < 116 or JTI if QRS ≥ 120)[d]	1.87	2.62	3.10	3.10	0.1880
Frequent VPB 9 (MC 8.1.2, 8.1.3,8.1.5)	0.50	0.46	0.09	1.92	0.4156
Sinus bradycardia (MC 8.8)	4.82	4.38	2.13 **	3.13	0.0165
Other minor abnormalities (MC 6.3,6.5,8.1.1,8.1.4,8.4.1,8.7,9.3.)	6.99	6.10	7.00	9.45	0.3870

Abbreviations: ECG, electrocardiogram; CVD, cardiovascular disease; LBBB, left bundle branch block; RBBB, right bundle branch block; IVCD, intraventricular conduction delay; VPB, ventricular premature beats.

[a] All values (except numbers of persons in headings) weighted for study design and non-response with use of SURVEY versions of SAS procedures. Numbers are age-adjusted means for continuous variables or prevalences (percents) of the indicated abnormality within each of the CVD risk factor groups.

[b] *, **, *** for 0.05, 0.01, 0.001 significance level for comparison with No CVD Risk Group.

[c] Age-adjusted p-value for trend from ordinal risk factor group variable in PROC SURVEYREG model.

[d] QT Index = (QT Duration/656) * (Heart Rate + 100) unless QRS duration > 120: then QT Index = ((QT dur - QRS dur) / 518) * (Heart Rate + 100).