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Association of occupational exposures with cardiovascular disease among US Hispanics/Latinos

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ABSTRACT

Objective Cardiovascular disease (CVD) is a leading cause of mortality and morbidity in the USA. The role of occupational exposures to chemicals in the development of CVD has rarely been studied even though many agents possess cardiotoxic properties. We therefore evaluated associations of self-reported exposures to organic solvents, metals and pesticides in relation to CVD prevalence among diverse Hispanic/Latino workers.

Methods Cross-sectional data from 7404 employed individuals, aged 18–74 years, enrolled in the Hispanic Community Health Study/Study of Latinos (HCHS/SOL) were analysed. Participants from four US cities provided questionnaire data and underwent clinical examinations, including ECGs. CVD was defined as the presence of at least one of the following: coronary heart disease, atrial fibrillation, heart failure or cerebrovascular disease. Prevalence ratios reflecting the relationship between each occupational exposure and CVD as well as CVD subtypes were calculated using Poisson regression models.

Results Hispanic/Latino workers reported exposures to organic solvents (6.5%), metals (8.5%) and pesticides (4.7%) at their current jobs. Overall, 6.1% of participants had some form of CVD, with coronary heart disease as the most common (4.3%) followed by cerebrovascular disease (1.0%), heart failure (0.8%) and atrial fibrillation (0.7%). For individuals who reported working with pesticides, the prevalence ratios for any CVD were 2.18 (95% CI 1.34 to 3.55), coronary heart disease 2.20 (95% CI 1.31 to 3.71), cerebrovascular disease 1.38 (95% CI 0.62 3.03), heart failure 0.91 (95% CI 0.23 to 3.54) and atrial fibrillation 5.92 (95% CI 1.89 to 18.61) after adjustment for sociodemographic, acculturation, lifestyle and occupational characteristics. Metal exposures were associated with an almost fourfold (3.78, 95% CI 1.24 to 11.46) greater prevalence of atrial fibrillation. Null associations were observed for organic solvent exposures.

Conclusions Our results suggest that working with metals and pesticides could be risk factors for CVD among Hispanic/Latino workers. Further work is needed to evaluate these relationships prospectively.

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BACKGROUND

Recent studies have linked working with certain chemicals to markers of adverse cardiovascular health such as increased blood pressure, arterial stiffness and decreased heart rate variability.[1–5] However, it remains unknown if exposures to these workplace hazards could manifest as cardiovascular disease (CVD). Cohort studies of aircraft maintenance workers, battery factory workers, miners and pesticide applicators exposed to solvents, metals and pesticides have found inconsistent relationships with rates of CVD death.[6–9] Although studies confined to specific occupations can be useful in identifying the health issues faced by particular types of workers, they are often limited by small sample sizes, ascertainment of clinical parameters, collection of lifestyle factors that could confound exposure–disease relationships and generalisability to wider populations. In addition, such studies are prone to bias from the healthy worker survivor effect since many occupations with high probabilities for exposure require employees meet certain standards of physical health.[10] As a result, measures of association for deleterious exposures can appear underestimated, or even biased so much that harmful risk factors appear protective. A community-based approach that captures a variety of occupations and industries may mitigate some of this bias by including individuals employed in less strenuous positions.

The assessment of occupational exposures in community-based studies is rare, in part because they are logistically difficult to validly measure on a large scale. A common approach is to link job titles to job-exposure matrices to infer probable exposures. However, misclassification can arise given that exposures may vary widely among individuals with the same title.[11] Moreover, the use of generic exposure matrices within a study comprised wholly of Hispanics/Latinos may not fully capture the work experiences of this distinct population. Hispanic/Latino workers may be disproportionately exposed to cardiotoxic agents compared with other racial/ethnic groups and uniquely vulnerable to workplace hazards because of language barriers, low educational attainment and limited resources. A lack of culturally appropriate job safety training coupled with fears surrounding job security and immigration status could make Hispanic/Latinos engaged in hazardous jobs even more susceptible to occupational illnesses. As an initial strategy, we used interviewer-administered questionnaires to examine cross-sectional associations of self-reported organic solvent, metal and pesticide occupational exposures with CVD.

METHODS

Study population

The Hispanic Community Health Study/Study of Latinos (HCHS/SOL) is a community-based prospective cohort study designed to evaluate risk factors and chronic diseases among the rapidly growing Hispanic/Latino population across four cities in the USA (Bronx, New York; Chicago, Illinois; Miami, Florida; and San Diego, California). HCHS/SOL included 16415 men and women, aged 18–74 years, who self-identified as Hispanic/Latino at baseline (2008–2011). The sampling design and cohort selection have been previously described.[12 13] Briefly, participants were recruited through a multistage probability sampling design. Sampling weights were established to represent the probability of selection at each stage. Baseline examinations included occupational information, sociodemographics, medical history, medication use, tobacco use, alcohol use, physical activity, dietary recall, anthropometry, blood pressure, phlebotomy and electrocardiography.

Exposure assessment

An occupational questionnaire designed to assess work environments and exposures was administered to all employed participants by a trained interviewer in either English or Spanish, based on the participant's preference. Participants were asked 'At the job you currently work the majority of your work hours per week, how often are you exposed to any type of organic solvents, for example styrene, trichloroethylene, toluene, or xylene?' and 'At the job you currently work the majority of your work hours per week, how often are you exposed to metals such as manganese, lead, or mercury?'. Response options were none of the time, 25% of the time, 50% of the time, 75% of the time, 100% of the time, occasionally and do not know. For this analysis, responses were collapsed into yes (occasional or 25%–100% of the time) or no (0%) because of data sparseness. Participants were also asked 'In your current job(s), are you exposed to pesticides?', with responses recorded as yes or no. Participants unfamiliar with the term 'pesticides' were classified as not exposed.

Outcome assessment

CVD prevalence was assessed using self-reported information from the medical history questionnaire or from a digital 12-lead ECG performed at baseline. Details regarding HCHS/SOL ECG procedures and subsequent readings performed at a centralised location (EPICARE, Wake Forest University School of Medicine, Winston-Salem, North Carolina) have been described elsewhere.[14] Prevalent CVD was defined as at least one of the following: coronary heart disease, heart failure, atrial fibrillation or cerebrovascular disease. Participants who self-reported that a doctor told them they had angina, a myocardial infarction or reported undergoing coronary bypass surgery, balloon angioplasty or stent placement in coronary arteries, or had ECG evidence of major Q wave abnormalities or minor Q, QS waves with ST and T abnormalities were considered to have coronary heart disease. Atrial fibrillation was defined as either a self-reported physician diagnosis or ECG evidence of atrial fibrillation or flutter. Heart failure was based solely on self-report (a doctor told the participant he or she had heart failure). Cerebrovascular disease was defined as self-reported physician diagnosis of stroke or transient ischaemic attack.

Sociodemographic characteristics

The interviewer-administered enrolment questionnaire asked participants for sociodemographic information. Hispanic/Latino background groups were categorised as Dominican, Central American, Cuban, Mexican, Puerto Rican, South American and more than one heritage/other heritage. Educational attainment was categorised as not having a high school diploma or General Equivalency Diploma (GED), having a diploma or GED or attaining an education beyond a high school equivalent (ie, college or vocational). Health insurance was defined as current coverage through an employer, individual plan, Medicaid/Medicare, military, Indian Health Services or another provider.

Lifestyle characteristics

Alcohol intake was classified as none, low/moderate (<7 drinks/week for females; <14 drinks/week for males) or heavy (≥7 drinks/week for females; ≥14 drinks/week for males). Cigarette smoking status was categorised as never, former or current. A modified Global Physical Activity Questionnaire based on the original developed by the WHO was used to collect information on physical activity in a typical week across three domains: work, recreation and transport. Total physical activity across these domains was categorised as low, moderate or high based on established criteria.[15] Dietary quality was assessed using the 2010 Alternative Health Eating Index (AHEI-2010), which was derived from up to two 24-hour dietary recalls. The index combines intakes of vegetables, fruit, whole grains, sugar-sweetened beverages and fruit juice, nuts and legumes, red/processed meats, trans fats, long-chain (n-3) fatty acids, polyunsaturated fatty acids, sodium and alcohol intakes, with higher scores representing a better quality diet.[16]

Acculturation characteristics

Residential duration in the mainland USA and the Short Acculturation Scale for Hispanics (SASH) language subscale were used as measures of acculturation. The SASH language subscale is based on five-point Likert-type scale questions; the average score was calculated with higher scores indicating a higher degree of language acculturation.[17]

Occupational characteristics

Full-time employment was defined as working more than 35 hours per week in one job or more than one job; part-time employment was defined as working 35 or fewer hours per week. Primary occupations were categorised into five groups: non-skilled workers (typically does not require a high school degree and involves manual labour), service workers (provides personal services to individuals), skilled workers (requires specific skills that typically requires technical training or certifications), professional/technical workers (requires a professional degree) and other. Participants were asked whether their current job was the same as their longest held job, and if so, how many years they worked at that job.

CVD risk factors

Participants were instructed to bring all medications (prescription and non-prescription) taken in the past month with them to the examination where they were scanned and documented. Medications were inventoried and classified using a Master Drug Data Base (Medispan MDDB). Three blood pressure measurements were performed using an automated sphygmomanometer (Omron model HEM-907 XL, Omron Healthcare, Bannockburn, Illinois, USA), with the average of the second and third readings calculated. Hypertension was defined as a systolic or diastolic blood pressure greater than or equal to 140/90 mm Hg, or the use of antihypertensive medications. Body weight

Table 1 Selected characteristics in relation to occupational exposures among participants currently employed in HCHS/SOL (n=7404)

		Current occupational exposure					
		Solvents†		Metals†		Pesticides†	
	Overall*	%	P values	%	P values	%	P values
Overall	–	6.5		8.5		4.7	
Centre			0.01		<0.01		<0.01
Bronx	25.2	4.9		7.6		6.5	
Chicago	18.9	8.5		12.5		4.2	
Miami	28.1	7.4		6.5		3.1	
San Diego	27.9	5.7		8.5		5.0	
Background			0.09		<0.01		0.12
Dominican	9.2	4.3		7.4		5.8	
Central American	8.9	9.1		9.0		4.1	
Cuban	17.3	7.6		7.3		2.8	
Mexican	42.0	6.5		10.4		4.8	
Puerto Rican	12.0	5.9		7.0		6.3	
South American	6.0	5.5		4.3		3.8	
Other/mixed	4.6	4.4		5.7		6.8	
Age (years)			0.11		<0.01		0.61
18–24	15.4	4.2		8.0		3.4	
25–34	25.8	6.9		11.2		5.1	
35–44	24.6	6.3		8.7		5.0	
45–54	20.9	7.9		7.0		4.6	
≥55	13.3	6.4		5.7		4.8	
Gender			<0.01		<0.01		<0.01
Female	45.1	2.9		3.5		2.8	
Male	54.9	9.5		12.5		6.2	
Residential duration in USA			0.58		0.87		0.03
<10 years	29.6	6.1		8.6		3.5	
≥10 years	70.4	6.6		8.4		5.2	
Employment status			<0.01		<0.01		0.38
Part time (≤35 hours/week)	34.2	4.5		6.0		4.2	
Full time (>35 hours/week)	65.8	7.5		9.7		4.9	
Primary occupation			<0.01		<0.01		0.28
Non-skilled worker	27.8	7.4		10.3		4.9	
Service worker	18.9	4.0		4.6		3.4	
Skilled worker	22.6	9.7		12.1		5.1	
Professional/technical	13.9	2.9		4.8		3.7	
Other	16.8	6.4		8.0		6.0	
Educational attainment			0.11		<0.01		0.33
No high school diploma/GED‡	26.3	7.0		9.9		5.6	
High school diploma/GED	28.1	7.5		10.4		4.0	
Greater than high school/GED	45.6	5.6		6.4		4.6	
Current health insurance			0.15		<0.01		0.02
No	53.2	7.0		9.6		3.8	
Yes	46.8	5.9		7.2		5.6	
SASH language subscale			0.05		0.04		0.28
1–<3 (low)	21.9	6.9		9.0		4.9	
≥3 (high)	78.1	5.1		6.7		3.9	
Physical activity level			<0.01		<0.01		<0.01
Low	18.9	3.8		4.6		3.0	
Medium	46.4	6.2		6.7		4.5	
High	34.7	12.3		20.0		8.4	
Alternative healthy eating index			<0.01		0.03		0.09
≤43.8 (low)	31.5	4.4		6.6		3.9	
>43.8–50.2 (medium)	32.3	7.3		8.8		4.2	

Continued

Table 1 Continued

		Current occupational exposure					
		Solvents†		Metals†		Pesticides†	
	Overall*	%	P values	%	P values	%	P values
>50.2 (high)	36.2	7.5		9.7		5.8	
Current alcohol intake			0.17		<0.01		<0.01
None	42.0	5.6		6.0		3.3	
Low/moderate	51.3	7.1		9.9		5.6	
Heavy	6.6	7.4		13.2		6.5	
Smoking status			0.05		<0.01		0.05
Never	64.2	5.8		7.5		4.2	
Former	17.6	7.1		8.6		4.2	
Current	18.2	8.3		11.7		6.9	
Hypertension			0.01		0.72		0.60
No	83.1	6.0		8.5		4.6	
Yes	16.9	9.0		8.2		5.1	
Hypercholesterolaemia			<0.01		0.29		0.31
No	60.8	5.6		8.1		4.3	
Yes	39.2	7.9		9.0		5.2	
Obese			0.25		0.31		0.42
No	63.0	6.8		8.8		4.4	
Yes	37.0	5.9		7.9		5.1	
Diabetes mellitus			0.27		0.92		0.57
No	89.9	6.4		8.5		4.6	
Yes	10.1	7.6		8.3		5.2	

*The overall column shows column percentages for all 7404 currently employed HCHS/SOL participants.
†The current occupational exposure columns show row percentages corresponding to currently employed HCHS/SOL participants who self-reported exposures to solvents, metals or pesticides, respectively.
GED, General Equivalency Diploma; HCHS/SOL, Hispanic Community Health Study/Study of Latinos; SASH, Short Acculturation Scale for Hispanics.

and height were measured by trained research technicians. Body mass index (BMI) was calculated as weight in kilograms divided by height in metres squared. Obesity was defined as a BMI of 30.0 kg/m^2 or greater.

Total cholesterol, high-density lipoprotein (HDL) cholesterol, low-density lipoprotein (LDL) cholesterol, glucose and glycated haemoglobin were measured from fasting blood samples at the HCHS/SOL Central Laboratory. Laboratory assay methodologies are further described in the HCHS/SOL Manual.[18] Hypercholesterolaemia was defined as a total cholesterol ≥240 mg/dL, LDL cholesterol ≥160 mg/dL, HDL cholesterol <40 mg/dL or antihyperlipidaemic medication use. Diabetes mellitus was defined as a fasting plasma glucose ≥126 mg/dL, 2-hour post-load plasma glucose ≥200 mg/dL, glycated haemoglobin ≥6.5% or antidiabetic medication use.

Statistical analyses

The prevalence of occupational exposures, CVD and CVD subtypes were calculated and compared across categorical variables using the Pearson χ^2 test. Poisson regression models were used to investigate the relationships between occupational exposures and CVD prevalence. Confounders were identified using a directed acyclic graph based on subject matter knowledge and the relevant epidemiological literature and were sequentially entered into models according to their hypothesised strengths of association with exposure status and CVD (online supplementary figure 1).[19] Adjusted model 1 included basic sociodemographic characteristics considered to be most strongly related to both exposure and CVD: age, gender, field centre and Hispanic/Latino background. Adjusted model 2 further adjusted for lifestyle and behavioural factors that were additionally considered to confound exposure–CVD associations, although not as strongly sociodemographic characteristics. These included employment status, current health insurance status, cigarette use, alcohol use level, years of residential duration in the USA, physical activity level and the AHEI-2010 and the SASH language subscale. Adjusted model 3 included all variables in adjusted model 2 and additionally included hypertension, hypercholesterolaemia, BMI and diabetes mellitus as these were hypothesised to be potential intermediates on the causal pathways that could potentially explain exposure–CVD relationships. In all models, restricted cubic splines with four equally spaced knots at the 5th, 35th, 65th and 95th percentiles were used for continuous variables (age, years of residential duration in the USA, AHEI-2010, SASH language subscale and BMI) to allow for non-linearity. P values less than 0.05 were considered statistically significant. All analyses were conducted in Stata V.14.2. The Stata *svy* prefix was used to incorporate the HCHS/SOL sampling weights and account for the complex sampling design.

Sensitivity analyses

Since solvent, metal and pesticide exposures in the participants' current job may not accurately reflect chronic exposures, we performed a sensitivity analysis restricting to participants who indicated their current held job was their longest held. The models were identical to those used in our main analyses, with the addition of years worked as a covariate.

RESULTS

Participants who did not know their solvent or metal exposure status were excluded from analyses (275 for solvents; 133 for

Table 2 Prevalence of cardiovascular disease and subtypes among participants currently employed in HCHS/SOL (n=7404)

Characteristic	Cardiovascular disease* %	P value	Coronary heart disease† %	P value	Cerebrovascular disease‡ %	P value	Atrial fibrillation§ %	P value	Heart failure¶ %	P value
Overall	6.1		4.3		1.0		0.7		0.8	
Centre		<0.01		<0.01		<0.01		0.02		0.09
Bronx	8.9		6.3		1.6		1.5		0.9	
Chicago	5.0		3.7		1.1		0.2		0.3	
Miami	6.1		4.2		1.0		0.6		0.7	
San Diego	4.4		3.0		0.3		0.3		1.3	
Background		<0.01		0.13		<0.01		<0.01		0.44
Dominican	6.8		4.4		0.8		1.4		0.7	
Central American	5.5		3.6		1.6		0.3		0.5	
Cuban	6.6		5.1		0.9		0.7		0.8	
Mexican	5.0		3.7		0.6		0.2		0.9	
Puerto Rican	10.6		6.4		2.3		2.6		1.4	
South American	4.9		3.3		1.0		0.1		1.1	
Other/mixed	3.4		3.1		0.4		0.2		0.0	
Age (years)		<0.01		<0.01		<0.01		0.63		<0.01
18–24	4.0		2.8		0.4		0.6		0.1	
25–34	3.1		2.3		0.4		0.4		0.2	
35–44	5.7		4.1		0.8		0.7		1.1	
45–54	7.3		4.5		1.7		0.6		1.3	
≥55	13.2		10.1		2.0		1.4		1.8	
Gender		0.05		<0.01		0.91		0.51		0.28
Female	5.2		3.1		1.0		0.5		1.0	
Male	6.9		5.2		1.0		0.8		0.7	
Residential duration in USA (years)		0.12		0.07		0.58		0.93		0.79
<10	5.1		3.4		0.8		0.6		0.8	
≥10	6.5		4.6		1.0		0.7		0.9	
Employment status		0.58		0.49		0.37		0.70		0.58
Part time (≤35 hours/week)	5.8		3.9		1.2		0.6		0.9	
Full time (>35 hours/week)	6.3		4.5		0.9		0.7		0.8	
Primary occupation		0.85		0.27		0.85		0.14		0.07
Non-skilled worker	5.9		3.9		1.0		1.2		0.6	
Service worker	5.9		4.5		0.9		0.1		1.1	
Skilled worker	6.0		3.9		1.1		0.6		1.1	
Professional/technical	5.8		3.4		0.9		0.9		1.4	
Other	7.1		6.0		0.7		0.4		0.2	
Educational attainment		0.18		0.3		0.32		0.20		0.85
No high school diploma/GED	7.0		5.1		1.3		0.8		0.7	
High school diploma/GED	5.0		3.6		0.9		0.2		0.9	
Greater than high school/GED	6.3		4.3		0.8		0.9		0.9	
Current health insurance		<0.01		<0.01		0.45		<0.01		0.14
No	4.6		3.2		0.9		0.2		0.6	
Yes	7.8		5.6		1.1		1.2		1.1	
SASH language subscale		0.84		0.27		0.24		0.03		0.40
1-<3 (low)	6.2		4.5		0.9		0.5		0.9	
≥3 (high)	5.9		3.5		1.3		1.5		0.6	
Physical activity level		0.03		0.23		0.25		0.27		0.07
Low	5.0		3.6		0.7		0.4		0.9	
Medium	7.2		4.8		1.2		0.9		1.0	
High	5.5		4.2		0.9		0.5		0.3	
Alternative healthy eating index		0.06		0.09		0.64		0.04		0.66
≤43.8 (low)	6.5		4.3		1.0		1.3		0.9	
>43.8–50.2 (medium)	4.7		3.3		0.8		0.5		0.7	
>50.2 (high)	7.1		5.2		1.1		0.3		0.9	

Continued

Table 2 Continued

	Cardiovascular disease*		Coronary heart disease†		Cerebrovascular disease‡		Atrial fibrillation§		Heart failure¶	
Characteristic	**%**	**P value**	**%**	**P value**	**%**	**P value**	**%**	**P value**	**%**	**P value**
Current alcohol intake		0.02		0.09		<0.01		0.01		0.28
None	6.6		4.3		1.4		1.0		1.1	
Low/moderate	5.2		3.9		0.7		0.3		0.7	
Heavy	10.2		7.4		0.3		2.1		0.4	
Smoking status		0.25		0.06		0.13		0.50		0.90
Never	5.7		3.6		0.9		0.8		0.8	
Former	6.2		5.0		0.7		0.4		1.0	
Current	7.5		5.9		1.4		0.6		0.8	
Hypertension		<0.01		<0.01		<0.01		<0.01		<0.01
No	4.6		3.3		0.7		0.5		0.6	
Yes	13.4		9.2		2.6		1.7		2.1	
Hypercholesterolaemia		<0.01		<0.01		0.05		0.95		0.09
No	5.1		3.2		0.8		0.7		0.7	
Yes	7.7		6.0		1.3		0.7		1.1	
Obese		<0.01		<0.01		0.08		0.79		0.48
No	5.2		3.3		0.8		0.7		0.8	
Yes	7.7		5.9		1.3		0.6		1.0	
Diabetes mellitus		<0.01		<0.01		<0.01		0.09		<0.01
No	5.3		3.7		0.8		0.6		0.6	
Yes	13.7		9.7		2.3		1.6		3.1	

*Cardiovascular disease was defined as at least one of the following: coronary heart disease, cerebrovascular disease, heart failure or atrial fibrillation; data are expressed as row percentages.
†Coronary heart disease was defined as self-reported angina, myocardial infarction, coronary bypass surgery, balloon angioplasty or stent placement in coronary arteries, or ECG evidence of major Q wave abnormalities or minor Q, QS waves with ST and T abnormalities; data are expressed as row percentages.
‡Cerebrovascular disease was defined as self-reported stroke or transient ischaemic attack; data are expressed as row percentages.
§Heart failure was defined as self-reported heart failure; data are expressed as row percentages.
¶Atrial fibrillation was defined as self-reported atrial fibrillation or ECG evidence of atrial fibrillation or flutter; data are expressed as row percentages.
GED, General Equivalency Diploma; HCHS/SOL, Hispanic Community Health Study/Study of Latinos; SASH, Short Acculturation Scale for Hispanics.

metals); however, they did not differ substantially from those who provided a definitive response in terms of Hispanic/Latino background, age, gender, educational attainment, language acculturation, nativity or CVD status (online supplementary table 1). After excluding these participants and those with incomplete data, our analytic sample included 7404 (91.1%) participants of the 8156 employed at baseline. Occupational exposures and participant characteristics are displayed in table 1. The most commonly reported exposure was to metals (8.5%), followed by solvents (6.5%) and pesticides (4.7%). Male gender, higher physical activity levels and current smoking were consistently associated with a higher probability of reporting working with chemical hazards. Overall, 6.1% of participants had CVD, of which the majority of cases were coronary heart disease (table 2). CVD was more common among Bronx field centre, Puerto Rican background, older age, insured, heavy alcohol consumption, hypertensive, hypercholesterolaemic, obese and diabetic participants.

In crude regression models, the prevalence of any CVD was more than twice (prevalence ratio (PR): 2.51, 95% CI 1.35 to 4.69) as high among participants who reported exposures to pesticides in their current job(s) compared with participants who did not (table 3). This association persisted after adjustment for confounders (adjusted model 2; PR: 2.18, 95% CI 1.34 to 3.55). The corresponding adjusted PRs for pesticide exposure were 2.20 (95% CI 1.31 to 3.71) for coronary heart disease, 1.38 (95% CI 0.62 to 3.03) for cerebrovascular disease, 5.92 (95% CI 1.89 to 18.61) for atrial fibrillation and 0.91 (95% CI 0.23 to 3.54) for heart failure. The adjusted PR for self-reported metal exposures in the primary job and any CVD from model 2 was 1.24 (95% CI 0.80 to 1.94). Metal exposures were significantly associated with atrial fibrillation (adjusted model 2; PR: 3.78, 95% CI 1.24 to 11.46), but not coronary heart disease, cerebrovascular disease or heart failure. Associations for self-reported solvent exposure in the primary job were largely null. Including hypertension, hypercholesterolaemia, BMI and diabetes mellitus (ie, adjusted model 3) in our models did not appreciably change the results (table 3; figures 1–3).

A total of 5080 participants were currently working at their longest held job, with the median duration of employment in that position being 10 years (IQR: 5–20 years). In sensitivity analyses of these individuals, the magnitude of the observed associations for metal and pesticide exposures was increased. For example, in our main analyses, self-reported metal exposure was associated with an approximately fourfold greater prevalence of atrial fibrillation (table 3), whereas for those whose current job was their longest held, the relative association was almost fivefold (table 4). Again, we observed no appreciable attenuation after adjusting for hypertension, hypercholesterolaemia, BMI or diabetes mellitus.

DISCUSSION

Between 4.7% and 8.5% of Hispanic/Latino workers in urban areas of the US report being exposed to organic solvents, metals or pesticides at their jobs. Occupational exposures to pesticides,

Table 3 Associations between occupational exposures and cardiovascular disease and subtypes (n=7404)

	Crude model	Adjusted model 1	Adjusted model 2	Adjusted model 3
	PR (95% CI)*	PR (95% CI)†	PR (95% CI)‡	PR (95% CI)§
Cardiovascular disease				
Solvents	1.03 (0.64 to 1.66)	0.93 (0.58 to 1.51)	0.94 (0.58 to 1.52)	0.92 (0.58 to 1.47)
Metals	1.21 (0.80 to 1.83)	1.26 (0.81 to 1.95)	1.24 (0.80 to 1.93)	1.22 (0.79 to 1.89)
Pesticides	2.51 (1.35 to 4.69)	2.25 (1.26 to 4.01)	2.18 (1.34 to 3.55)	2.18 (1.34 to 3.56)
Coronary heart disease				
Solvents	1.12 (0.67 to 1.86)	0.97 (0.59 to 1.60)	0.96 (0.59 to 1.57)	0.96 (0.59 to 1.57)
Metals	1.05 (0.65 to 1.69)	1.01 (0.61 to 1.67)	0.97 (0.59 to 1.59)	0.98 (0.60 to 1.59)
Pesticides	2.85 (1.30 to 6.26)	2.47 (1.24 to 4.90)	2.20 (1.31 to 3.71)	2.24 (1.29 to 3.90)
Cerebrovascular disease				
Solvents	0.70 (0.25 to 1.97)	0.59 (0.20 to 1.70)	0.59 (0.20 to 1.76)	0.60 (0.22 to 1.64)
Metals	0.59 (0.24 to 1.42)	0.65 (0.25 to 1.67)	0.67 (0.26 to 1.76)	0.64 (0.25 to 1.65)
Pesticides	1.48 (0.67 to 3.24)	1.33 (0.58 to 3.04)	1.38 (0.62 to 3.03)	1.42 (0.64 to 3.14)
Atrial fibrillation				
Solvents	1.34 (0.20 to 8.97)	1.46 (0.21 to 10.23)	1.62 (0.32 to 8.31)	1.25 (0.28 to 5.47)
Metals	2.45 (0.73 to 8.27)	2.88 (0.81 to 10.29)	3.78 (1.24 to 11.46)	3.93 (1.41 to 11.00)
Pesticides	4.00 (1.10 to 14.51)	3.52 (0.80 to 15.46)	5.92 (1.89 to 18.61)	5.61 (1.97 to 16.03)
Heart failure				
Solvents	0.36 (0.10 to 1.30)	0.38 (0.10 to 1.41)	0.40 (0.11 to 1.48)	0.41 (0.11 to 1.51)
Metals	0.91 (0.18 to 4.49)	1.27 (0.22 to 7.15)	1.53 (0.27 to 8.69)	1.56 (0.28 to 8.64)
Pesticides	0.85 (0.22 to 3.30)	0.86 (0.23 to 3.27)	0.91 (0.23 to 3.54)	0.92 (0.23 to 3.70)

*Prevalence ratio (PR) with 95% CI comparing self-reported exposure to the respective agent to no exposure.
†PR with 95% CI comparing self-reported exposure to the respective agent to no exposure with adjustment for age (restricted cubic splines with four knots), gender (male/female), field centre (Bronx, Chicago, Miami or San Diego) and Hispanic/Latino background (Dominican, Central American, Cuban, Mexican, Puerto Rican, South American or other/mixed).
‡PR with 95% CI comparing self-reported exposure to the respective agent to no exposure with adjustment for the variables listed in † with additional adjustments for current health insurance status (yes/no), cigarette use (current, former or never), alcohol use level (none, low/moderate or high) years of residential duration in the USA (restricted cubic splines with four knots), employment status (full time or part time), physical activity level (low, medium or high), alternative healthy eating index (restricted cubic splines with four knots) and the Short Acculturation Scale for Hispanics – language subscale (restricted cubic splines with four knots).
§PR with 95% CI comparing self-reported exposure to the respective agent to no exposure with adjustment for the variables listed in † with additional adjustments for hypertension (yes/no), hypercholesterolaemia (yes/no), body mass index (restricted cubic splines with four knots) and diabetes mellitus (yes/no).

and to a lesser degree metals, were positively associated with CVD, while no associations were observed for organic solvents. Given the stronger results found when restricting analyses to participants whose current job was their longest held, it appears that cumulative exposures are more harmful. Prior work within the HCHS/SOL cohort suggests workplace metals and pesticide exposures are unrelated to cardiometabolic conditions.[5] The lack of attenuation by hypertension, hypercholesterolaemia, diabetes and BMI in the present analysis further supports this hypothesis and suggests that alternative biological mechanisms may play a role in the development of metal-association and pesticide-associated CVD.

Little is known about the effects of chronic, low-level pesticide and metal exposures on the development of CVD. Of

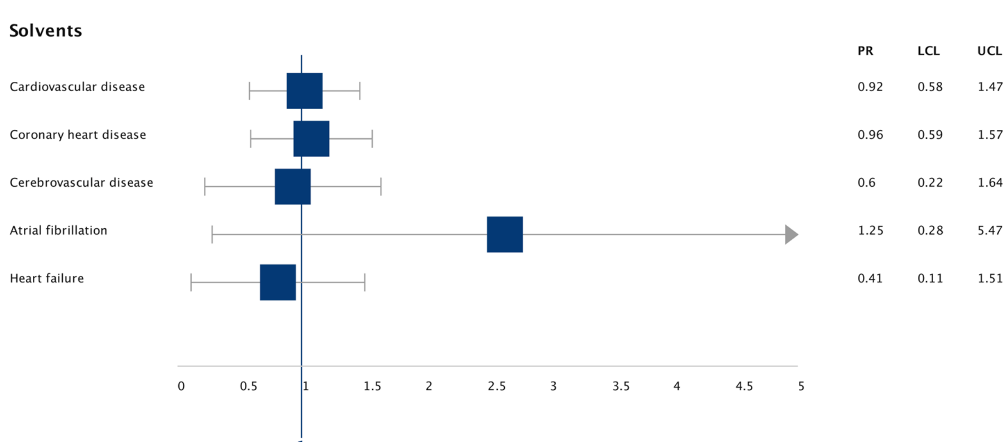

Figure 1 PRs with 95% CI for current occupational exposure to solvents and cardiovascular disease after adjustment for age, gender, field centre, Hispanic/Latino background, current health insurance status, cigarette use, alcohol use level, years of residential duration in the USA, employment status, physical activity level, alternative healthy eating index, Short Acculturation Scale for Hispanics – language subscale, hypertension, hypercholesterolaemia, body mass index and diabetes mellitus. LCL, lower confidence limit; PR, prevalence ratio; UCL, upper confidence limit.

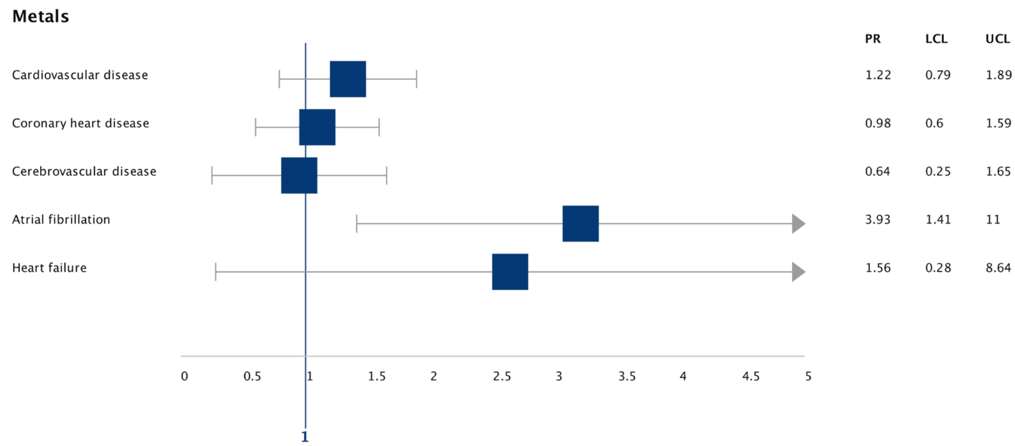

Figure 2 PRs with 95% CI for current occupational exposure to metals and cardiovascular disease after adjustment for age, gender, field centre, Hispanic/Latino background, current health insurance status, cigarette use, alcohol use level, years of residential duration in the USA, employment status, physical activity level, alternative healthy eating index, Short Acculturation Scale for Hispanics – language subscale, hypertension, hypercholesterolaemia, body mass index and diabetes mellitus. LCL, lower confidence limit; PR, prevalence ratio; UCL, upper confidence limit.

the CVD subtypes, the strongest cross-sectional relationships with pesticide use were observed for coronary heart disease and atrial fibrillation. The underlying mechanisms of pesticide cardiotoxicity relevant for such diseases include degeneration of myocardial fibres, modification of sodium channels and reduced intracellular uptake of calcium, all of which have been observed in animal studies.[20–22] For metals, epidemiological studies have produced suggestive evidence of a causal relationship with CVD, but the number of studies is small.[23 24] In our analyses, the only CVD subtype significantly associated with occupational metal exposures was atrial fibrillation. This is a novel finding and is biologically plausible since metals can induce both systemic (eg, oxidative stress and inflammation) and direct effects on the heart and vasculature (eg, impaired left ventricular function and degeneration of arterial compliance).[23] While there is some evidence that exposure to certain organic solvents adversely affects cardiac health and function, we did not observe any significant associations in our analyses.[1 5 6]

Though our results are intriguing, this work is not without limitations. We relied on self-reported information about exposures from questionnaires, which may have been misreported. The questionnaires used recognised strategies for accurate responses by prompting participants with recognisable terms (eg, 'metals') that did not allow for open-ended responses.[25] We dichotomised exposure as yes/no because the data regarding frequency of exposure were sparse. Thus, we were unable to conduct dose–response analyses. One potential benefit of collapsing exposure status is that we may have limited exposure misclassification as the reliability of self-reported frequency of exposures tends to be lower than the reliability of self-reported exposure status itself.[26] Ultimately, we have no reason to believe that any exposure misclassification would be associated with CVD status. Some of the CVD endpoints used in this study were also ascertained via self-report; however, many have been shown to have high validity and were combined with electrocardiographic evidence.[27–29] Nevertheless, there remains the potential for recall bias and/or reverse causality if those with existing disease were more likely to report their occupational exposures or if diseased individuals were more

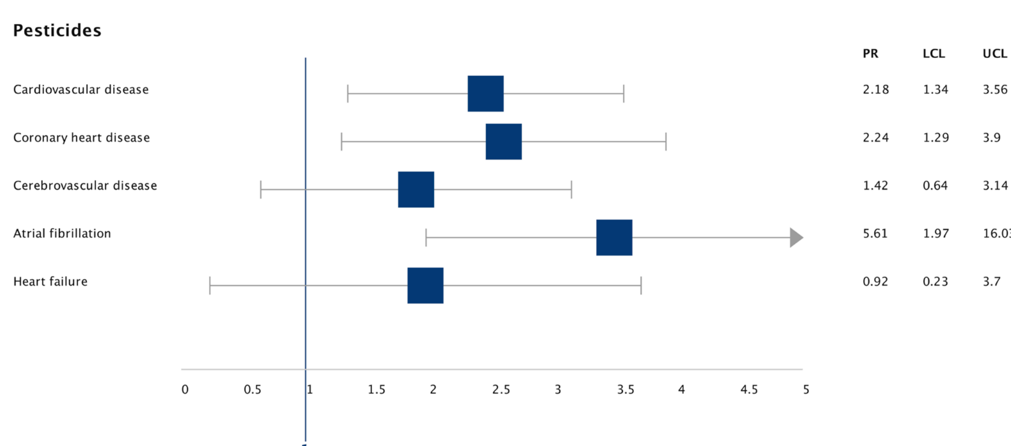

Figure 3 PRs with 95% CI for current occupational exposure to pesticides and cardiovascular disease after adjustment for age, gender, field centre, Hispanic/Latino background, current health insurance status, cigarette use, alcohol use level, years of residential duration in the USA, employment status, physical activity level, alternative healthy eating index, Short Acculturation Scale for Hispanics – language subscale, hypertension, hypercholesterolaemia, body mass index and diabetes mellitus. LCL, lower confidence limit; PR, prevalence ratio; UCL, upper confidence limit.

Table 4 Associations between occupational exposures and cardiovascular disease and subtypes among participants whose current job was their longest held (n=5080)

	Crude model	Adjusted model 1	Adjusted model 2	Adjusted model 3
	PR (95% CI)*	PR (95% CI)†	PR (95% CI)‡	PR (95% CI)§
Cardiovascular disease				
Solvents	1.18 (0.67 to 2.07)	1.14 (0.66 to 1.97)	1.20 (0.70 to 2.08)	1.16 (0.69 to 1.98)
Metals	1.38 (0.85 to 2.23)	1.44 (0.85 to 2.43)	1.43 (0.85 to 2.38)	1.44 (0.88 to 2.35)
Pesticides	3.36 (1.71 to 6.60)	2.80 (1.55 to 5.05)	2.61 (1.64 to 4.14)	2.59 (1.67 to 4.03)
Coronary heart disease				
Solvents	1.32 (0.72 to 2.44)	1.19 (0.67 to 2.11)	1.20 (0.69 to 2.08)	1.17 (0.68 to 2.02)
Metals	1.21 (0.69 to 2.13)	1.12 (0.61 to 2.06)	1.09 (0.63 to 1.88)	1.13 (0.66 to 1.94)
Pesticides	4.25 (1.82 to 9.90)	3.20 (1.73 to 5.91)	2.44 (1.61 to 3.70)	2.47 (1.64 to 3.73)
Cerebrovascular disease				
Solvents	0.90 (0.29 to 2.80)	0.84 (0.26 to 2.77)	1.03 (0.35 to 3.06)	1.07 (0.37 to 3.09)
Metals	0.62 (0.22 to 1.76)	0.72 (0.23 to 2.24)	0.78 (0.26 to 2.34)	0.82 (0.30 to 2.25)
Pesticides	1.32 (0.48 to 3.66)	1.25 (0.44 to 3.56)	1.38 (0.51 to 3.75)	1.46 (0.52 to 4.06)
Atrial fibrillation				
Solvents	1.37 (0.20 to 9.28)	1.77 (0.26 to 12.02)	2.98 (0.87 to 10.26)	2.41 (0.98 to 5.95)
Metals	2.42 (0.69 to 8.51)	3.38 (1.04 to 11.02)	4.89 (2.01 to 11.95)	5.15 (2.15 to 12.38)
Pesticides	4.36 (1.17 to 16.21)	3.73 (0.80 to 17.48)	8.21 (3.21 to 21.02)	7.34 (3.17 to 16.96)
Heart failure				
Solvents	0.30 (0.06 to 1.45)	0.33 (0.07 to 1.64)	0.37 (0.08 to 1.79)	0.36 (0.07 to 1.82)
Metals	0.83 (0.13 to 5.41)	1.11 (0.15 to 8.08)	1.29 (0.18 to 9.11)	1.29 (0.25 to 6.65)
Pesticides	0.71 (0.13 to 3.91)	0.80 (0.15 to 4.30)	0.84 (0.15 to 4.76)	0.82 (0.13 to 5.04)

*Prevalence ratio (PR) with 95% CI comparing self-reported exposure to the respective agent with no exposure.
†PR with 95% CI comparing self-reported exposure to the respective agent to no exposure with adjustment for age (restricted cubic splines with four knots), gender (male/female), field centre (Bronx, Chicago, Miami or San Diego) and Hispanic/Latino background (Dominican, Central American, Cuban, Mexican, Puerto Rican, South American or other/mixed).
‡PR with 95% CI comparing self-reported exposure to the respective agent to no exposure with adjustment for the variables listed in † with additional adjustments for current health insurance status (yes/no), cigarette use (current, former or never), alcohol use level (none, low/moderate or high) years of residential duration in the USA (restricted cubic splines with four knots), employment status (full time or part time), physical activity level (low, medium or high), alternative healthy eating index (restricted cubic splines with four knots) and the Short Acculturation Scale for Hispanics – language subscale (restricted cubic splines with four knots).
§PR with 95% CI comparing self-reported exposure to the respective agent to no exposure with adjustment for the variables listed in † with additional adjustments for hypertension (yes/no), hypercholesterolaemia (yes/no), body mass index (restricted cubic splines with four knots) and diabetes mellitus (yes/no).

willing to work with hazardous substances. Because we did not collect agent-specific information, we are unable to attribute the observed associations to individual metals or pesticides. Lastly, our questionnaires only queried participants with regards to their chemical exposures at work, so we were unable to assess the contribution of any exposures from leisure-time activities.

As a community-based study, this work was the first to evaluate the role of workplace chemical exposures in CVD among urban Hispanic/Latino workers. Though relatively rare in this population, metal and pesticide exposures in the workplace were cross-sectionally associated with marked elevations in the prevalence of CVD. These results should be considered preliminary and interpreted with caution given the limitations of our study design; namely, our reliance on self-reported exposure status and cross-sectional data. However, our results do suggest occupational exposures could be important contributors to CVD for Hispanics/Latinos. The findings from the present analysis are consistent with prior studies within the HCHS/SOL cohort and highlight the substantial burden of chronic disease risk factors and CVD in the US Hispanic/Latino population.[30] A major discovery is that US Hispanics/Latinos are not a homogenous group; there exists substantial heterogeneity by Hispanic/Latino background and gender.[30] Notably, Puerto Rican individuals and men were significantly more likely to suffer from CVD than their peers. In our study, the proportion of Puerto Ricans reporting workplace exposures was on par with most of the other background groups; however, men reported exposures 2–3 fold more than women. Since workplace chemical hazards are known risk factors for other

Key messages

What is already known on this subject?

- Some industrially used chemicals are known cardiotoxins. Both acute and long-term exposures can result in damages to the cardiovascular system.

What might this study add?

- Here, we estimate the proportion of exposed US Hispanic/Latino workers, a large and growing minority population that may especially vulnerable and quantify associations with prevalent cardiovascular disease. Our findings suggest between 5% and 9% of employed Hispanics/Latinos are exposed to solvents, metals or pesticides in the workplace.
- Occupational exposures to metals or pesticides, in particular, were associated with an elevated prevalence of coronary heart disease and atrial fibrillation.

How might this impact on clinical practice?

- Clinicians should consider the value of taking an occupational history during medical examinations, as doing so could assist in identifying workplace hazards that need to be controlled.

serious illnesses, including cancers, respiratory and neurological conditions, efforts should be undertaken to minimise or eliminate exposures. Such workplace interventions may want to consider first targeting male workers, especially Puerto Rican males given their double burden of occupational exposures and existing CVD.

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Contributors CMB performed all statistical analyses and wrote the manuscript. MLD, VWP, RAD-A and MA were integrally involved in the study design and manuscript preparation. JPL, TE, DJL, ARR and WT each critically revised the manuscript with regards to data interpretation.

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