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Immigrant status and cardiovascular risk over time: Results from the Multi-Ethnic Study of Atherosclerosis

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Abstract

Purpose—Despite cross-sectional evidence that foreign-born United States (US) residents often have better health than US-born residents of similar race/ethnicity, we know little about overall cardiovascular risk progression over time among immigrants as they age in the US.

Methods—Using longitudinal data from the Multi-Ethnic Study of Atherosclerosis on 6446 adults aged 45–84 years at baseline, we examined how nativity and length of US residence related to change in cardiovascular health and cardiovascular event incidence over 11-year follow-up. Cardiovascular health was measured using the American Heart Association's cardiovascular health (CVH) measure (range 0–14; higher is better).

Results—Immigrants, particularly those with shorter US residence, had better baseline cardiovascular health and lower cardiovascular event incidence than the US-born. Baseline CVH scores ranged from 8.67 (8.42–8.92) among immigrants living in the US < 10 years to 7.86 (7.76–7.97) among the US-born. However, recent immigrants experienced the largest CVH declines over time: 10-year declines ranged from −1.04 (−1.27–−0.80) among immigrants living in the US < 10 years at baseline to −0.47 (−0.52–−0.42) among the US-born.

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DISCLOSURES
None.

Conclusions—Public health prevention efforts targeting new immigrants may help slow the deterioration of cardiovascular health and reduce future cardiovascular risk.

Keywords

cardiovascular events; immigrants; cohort studies; cardiovascular risk factors

INTRODUCTION

Immigrants to the United States (US) often display better health and lower mortality relative to US-born groups of similar race/ethnicity, net of socioeconomic differences.[1-4] Hypothesized mechanisms driving this "immigrant advantage" include positive health selection of immigrants from originating populations; negative health selection of ailing immigrants back to their countries of origin; cultural differences in health-related behavioral norms; and supportive familial and social networks among immigrant groups. [2,5,6] However, longer length of US residence among immigrants is related to narrower health differentials by nativity.[4,7-9] One explanation is that acculturation—adoption of US behavioral and social norms—leads to poorer health behaviors and the erosion of social and familial ties that are critical to good health.[4,8] The vast majority of research examining the immigrant advantage and length of US residence has been cross-sectional. This is problematic in part because observed associations between length of US residence and health can be confounded by differences across immigrant arrival cohorts. Emerging longitudinal research has begun to document progression of cardiovascular risk in immigrants over time, but these studies have focused almost exclusively on single risk factors.[10-12] Therefore, we know relatively little about how nativity and length of US residence relate to the progression of overall cardiovascular risk over time.

Research on the immigrant advantage with respect to specific behavioral and clinical cardiovascular risk factors is mixed. Poorer diet and a higher prevalence of obesity have been consistently associated with being US-born or with longer length of US residence among the foreign born.[7,13] Longer US residence has been related to higher smoking prevalence among Asian and Hispanic immigrant women while results among men are less consistent.[14,15] The foreign-born are less likely to meet overall physical activity recommendations than the US-born, but also to have less sedentary behavior.[8,16-18] US birth and longer US residence have also been associated with higher prevalence of diabetes, hypercholesterolemia, and hypertension, but the presence and strength of these associations varies across studies.[19-22] If residence in the US contributes to accelerated progression of overall cardiovascular risk, interventions targeted to recent immigrants may be an effective way to reduce future cardiovascular disease burden in immigrant populations.

We used 11 years of longitudinal data from the Multi-Ethnic Study of Atherosclerosis, a multi-site, multiethnic cohort study of older adults to examine how nativity and baseline length of US residence related to change over time in overall cardiovascular health and to incidence of cardiovascular (CV) events . Our measure of overall cardiovascular health was the ideal cardiovascular health (CVH) measure developed by the American Heart Association in 2010, which incorporates the "Life's Simple 7" metrics: smoking, diet, physical activity, obesity, total cholesterol, blood pressure, and fasting glucose.[23] We hypothesized that foreign-born participants would have better CVH and experience fewer CV events during follow-up than US-born participants of the same racial/ethnic background, and that these advantages would be largest for recent immigrants. We also hypothesized that foreign-born participants, particularly more recent immigrants, would experience faster declines in CVH over time than the US-born. Faster progression in cardiovascular risk factors over time among recent immigrants may stem from the abrupt behavioral and social changes that occur in the period soon after migration, as well as stress associated with the migration process itself.[4,10,21,24] Finally, we examined whether these associations varied by baseline age.[13,25,26] As older immigrants may be less likely to assimilate to unhealthy behavior patterns in the US,[13] we hypothesized that cardiovascular risk among younger immigrants would converge to that of the US-born more quickly than among older participants.

MATERIALS AND METHODS

Study Population

Data came from the Multi-Ethnic Study of Atherosclerosis (MESA), a cohort study of 6814 adults aged 45–84 years and free of clinical cardiovascular disease at baseline, recruited from six sites (Forsyth County, NC; New York City, NY; Baltimore, MD; St. Paul, MN; Chicago, IL; and Los Angeles, CA). Population-based methods were used to recruit participants from four racial/ethnic groups: non-Hispanic white, non-Hispanic black, Hispanic, and Chinese.[27] Baseline exams were conducted in 2000–2002, with four additional follow-up waves in 2002–2003, 2004–2005, 2006–2007, and 2010–2012. Study design details are available elsewhere.[27] The study was approved by the Institutional Review Boards at each site and all participants gave written informed consent. After exclusion of participants with incomplete information, our analysis sample included n = 6446 (95% of the original sample) for CVH score analyses and n = 6515 (96%) for CV event analyses.

Measures

As defined by the American Heart Association, CVH score was calculated incorporating 3 behavioral (smoking, diet, and physical activity) and 4 clinical metrics (obesity, total cholesterol, blood pressure, and fasting glucose).[23] In keeping with previous research, each participant was assigned a value of 0, 1, or 2 corresponding to poor, intermediate, or ideal status, respectively, for each metric (Table 1).[23] The values were then summed across the 7 metrics to create a total CVH score ranging 0–14 for each exam wave.[28,29] Higher values correspond to better cardiovascular health.

Smoking status was self-reported and included information about timing, duration, and quantity of current and past smoking. Physical activity was measured using a 28-item survey asking participants about the frequency, duration, and intensity of their participation in a variety of activity categories (e.g., work, walking, sports) during a typical week in the past month.[30] Categories were sample tertiles of total minutes of moderate activity per week, with minutes of vigorous activity double counted. Results were similar using the absolute cut-offs described in the original CVH measure,[23] but the MESA questionnaire likely resulted in overestimates of physical activity time; tertiles also yielded a distribution more closely approximating that of other US samples.[23,31,32]

Diet was measured using a food frequency questionnaire based on the Insulin Resistance Atherosclerosis Study instrument, which had comparable validity among non-Hispanic white, non-Hispanic black, and Hispanic persons, and modified to include foods typically eaten in Chinese populations.[27] Categories were based on the number of the following healthy diet components that were met: ≥ 4.5 servings of fruit or vegetables/day, ≥ 2 servings of fish/week, ≥ 3 servings of whole grains/day, < 1500 mg sodium/day, and < 3 servings of sugar-sweetened beverages/week. Because diet information was not collected in study waves 2–4 and physical activity information was not collected in wave 4, participants were assigned the value from the nonmissing exam closest in date. Body mass index, total cholesterol, blood pressure, and fasting blood glucose were all measured by study staff using standard procedures.[23,29]

CV event incidence information was collected through telephone interviews at 9–12-month intervals from baseline through 2012. All death certificates and inpatient medical records, and selected outpatient records, as well as next-of-kin interviews for out-of-hospital cardiovascular deaths, were reviewed by pairs of physicians (cardiologists or cardiovascular physician epidemiologists for non-neurovascular endpoints; neurologists for neurovascular endpoints) and disagreements were adjudicated by the full MESA event review committee to verify and classify events. We used a composite CV event measure including myocardial infarction; resuscitated cardiac arrest; angina (definite, or probable if followed by revascularization); stroke; or death attributed to stroke, coronary heart disease, or another atherosclerotic or cardiovascular disease cause.

Nativity status and length of US residence were reported by participants at baseline. We combined these measures into a single categorical measure (“time in US”) with US-born participants in one category and foreign-born participants categorized as having lived in the US < 10, 10–19, 20–29, or ≥ 30 years at baseline.

Potential baseline confounders included sex, age, race/ethnicity (non-Hispanic white, non-Hispanic black, Chinese, Mexican, or other Hispanic), marital status (married or cohabiting; divorced, separated, or widowed; or never married), and years of education. Participants selected their education from 8 categories; continuous years of education was assigned as the interval midpoint of the selected category. Potential time-varying covariates included study site, annual family income, employment status (working full-time, working part-time, retired, or other), and years since baseline.

Analysis

All analyses were conducted using SAS software, version 9.3 (SAS Institute, Cary, NC). We used chi-square tests and ANOVA to investigate unadjusted associations of time in US with CV health score, age-standardized CV event incidence, and covariates.

We used multilevel linear regression with random individual-level intercepts to estimate adjusted differences in baseline CVH score and changes in CVH score over time associated with categories of baseline time in US. We included product terms between elapsed study years and the time in US categories to test our hypothesis that declines in CVH over time differ by baseline time in US. We included a squared term for baseline age because of evidence of a nonlinear association with CVH score. A sensitivity analysis additionally including random individual-level time slopes did not affect results.

We used Cox proportional hazards regression to estimate adjusted associations of baseline time in US with CV event incidence. We used age as the time scale and accounted for left truncation from variability across participants in age at study entry.[33,34] We used Schoenfeld residuals to assess the proportional hazards assumption.[35] Because of a monotonic and approximately linear (on the log scale) association between baseline time in US and CV event incidence in the models using indicators for the baseline time in US categories, as well as a small number of CV events in some categories, we repeated the CV event analysis with the baseline time in US categories modeled as a single ordinal variable.

Income, employment status, and marital status were excluded from final models of both CVH score and CV events because their inclusion did not affect estimates for time in US. To test our hypothesis that associations between time in US and the outcomes differ by baseline age, we repeated analyses with separate models for participants aged < 65 years and ≥ 65 years at baseline.

In a sensitivity analysis, we repeated analyses incorporating time-varying inverse-probability-of-attrition weights (IPAWs) to account for differential attrition that might bias our estimates. Stabilized IPAWs were calculated from probabilities of loss to follow-up and death estimated for each participant at each MESA exam using separate pooled logistic regression models for loss to follow-up and death (all deaths for the CVH analysis; non-CVD-related deaths for the CV event analysis).[36] Models included the analysis variables along with additional variables predictive of loss to follow-up and death in the MESA sample. We also conducted subgroup analyses among Chinese and Hispanic participants, the two groups in our sample including the most foreign-born participants.

RESULTS

Twenty-nine percent of participants were foreign-born, including 4% (of all participants) who had lived in the US < 10 years at baseline, 6% for 10–19 years, 7% for 20–29 years, and 12% ≥ 30 years. Table 2 shows distributions of key measures and their bivariate associations with time in US. Compared to the US-born, foreign-born participants were more likely to be Chinese or Hispanic, to have low education, and to be from the Los Angeles or New York study sites. The pooled sample mean CVH score was 8.03; scores spanned the entire possible range (0–14). Longer baseline time in US was associated with lower CVH scores and higher CV event incidence. Distributions of the 7 CVH metrics were similar to national estimates;[32] ideal status was most prevalent for smoking (87% of the sample) and least prevalent for diet (1%) (not shown). Prevalence of ideal status was higher among US-born participants for physical activity and fasting blood glucose, and higher among foreign-born participants for the other metrics (Figure 1).

Table 3 shows CVH score regression results. After adjustment for covariates, less time in US was monotonically associated with higher (i.e., better) baseline CVH scores. The adjusted mean score was 9.86 ([95% confidence interval] 7.76, 7.97) among the US-born while among immigrants mean scores were 8.08 (7.93, 8.23) for having lived in the US ≥ 30 years, 8.46 (8.26, 8.67) for 20–29 years, 8.48 (8.27, 8.70) for 10–19 years, and 8.67 (8.42, 8.92) for < 10 years (overall $p < .001$). However, as hypothesized, being foreign-born— particularly having lived in the US < 10 years at baseline—was associated with steeper declines in CVH scores over time (overall p-interaction < .001). For example, the estimated mean 10-year decline in CVH score was over twice as large among the foreign-born living in the US < 10 years at baseline as among the US-born: −1.04 (−1.27, −0.80) and −0.47 (−0.52, −0.42), respectively. Ten-year declines among longer-term immigrants were intermediate between these two extremes. Although not the focus of this analysis, exploratory analyses suggested that the steeper declines among recent immigrants may have resulted more from larger declines in the clinical metrics (BMI, fasting glucose, cholesterol, and blood pressure) compared to the US-born than from relative declines in the behavioral metrics (see Supplementary Table).

Models incorporating IPAWs produced nearly identical results. Estimates were also consistent in direction and magnitude in race/ethnicity-specific analyses of Chinese and Hispanic participants, although results among the foreign-born were not always statistically different from the US-born in these subgroup analyses (at $\alpha = .05$), which had far smaller sample sizes. Hispanic participants had poorer CVH compared to Chinese participants

In models stratified by baseline age, time-in-US-related differences in baseline CVH scores were larger among participants aged < 65 years at baseline (Table 3). The pattern of larger declines in CVH over time among immigrants was also more pronounced among participants aged < 65 years at baseline. Among these younger participants, 10-year CVH declines were statistically significantly larger for all foreign-born participants, regardless of time in US, compared to the US-born. Among older participants, nativity-related differences in CVH declines were smaller and only statistically significantly different from the US-born for those living in the US < 10 years at baseline. This result is consistent with our hypothesis that cardiovascular risk among younger immigrants would converge to that of the US-born more quickly than among older participants.

There were 624 incident cardiovascular events during the follow-up period, with an overall incidence rate of 10.5 events per 1000 person-years. Figure 2 shows adjusted hazard ratios (HRs) of CV events from the Cox proportional hazards model including separate indicators for the categories of time in US, with US-born as the referent group. There was a strong graded relationship between longer baseline time in US and higher CV event incidence, although 95% confidence intervals were wide because of small numbers of events in some categories. Table 4 shows results from adjusted models including a single ordinal variable for the time in US categories, rather than the separate indicators used for the model in Figure 2. Each category of longer baseline time in US was associated with a 1.29 times higher hazard of a CV event (HR = 1.29 [1.12–1.49]).

IPAW and subgroup models produced similar results, although the HR was somewhat larger among Chinese than among Hispanic participants (HR = 1.45 [1.08–1.94] and HR = 1.16 [0.95–1.43], respectively). As with the CVH score outcome, associations between time in US and CV event incidence were more pronounced among younger participants: for each category higher time in US, HR = 1.48 (1.15–1.90) among participants aged < 65 years at baseline and HR = 1.19 (0.99–1.42) among participants aged ≥ 65 years at baseline.

DISCUSSION

In a multi-site, multi-ethnic sample of older adults in the US, being foreign-born and having lived in the US for less time at baseline were associated with better cardiovascular health and lower incidence of cardiovascular events, but faster declines in cardiovascular health over time. Our results contribute to limited prior research on nativity-based differences in the progression of overall cardiovascular risk as individuals age over time.

Our CVH score results are generally consistent with previous, mostly cross-sectional, literature documenting lower cardiovascular risk among immigrants than the US-born and higher risk among immigrants residing longer in the US than among newer arrivals.[37-39] Results from recent longitudinal studies of individual cardiovascular risk factors have shown that while immigrants may experience smaller increases in BMI or waist circumference over time relative to the US-born,[10] thus maintaining a weight-related health advantage, immigrants also paradoxically have lower levels of physical activity over time[12] and a higher incidence of diabetes.[11]

We also used our longitudinal data to document differences by nativity and time in US in CV event incidence. Despite a landmark series of papers in the 1980s–90s from the Ni-Hon-San study documenting CV event differences between Japanese men living in Japan, Hawaii, and California,[40,41] research examining these differences in contemporary or ethnically diverse populations is sparse.[42] Our results were consistent with two recent studies finding lower stroke incidence among foreign-born than US-born Hispanics [43] and lower incidence of both acute myocardial infarction and premature stroke among more recent immigrants to Canada.[44,45]

Our results complement and strengthen these previous findings in three key ways. First, we used longitudinal data to document not only cross-sectional differences in overall cardiovascular risk between groups but also differences in how this risk progresses with age. This distinction is important for disentangling differences in longitudinal progression of risk from differences between different arrival cohorts. Second, we used a recently developed measure of overall cardiovascular health that is of current relevance in national efforts to improve population health and reduce cardiovascular disease.[23] CVH has been strongly predictive of cardiovascular events and mortality in multi-ethnic populations[31,46-48] but longitudinal changes in the score, and associations with time in US, have rarely been examined.[49,50] Third, we examined differences in these associations between younger and older immigrants. From a life course perspective, it is difficult to disentangle effects of age at immigration from those of length of US residence because of their linear dependency (length of US residence = age – age at immigration). While our analysis cannot fully distinguish between the two, it does suggest that changes in CVD risk progression associated with length of US residence may in fact differ by age at immigration.

In our age-stratified models, the nativity and time-in-US differences we observed were more pronounced among participants aged < 65 years at baseline. Steeper declines in CVH over time among the foreign-born in CVH were more pronounced among younger participants, as we hypothesized, but so were the relative advantages in baseline CVH and in CV event incidence. One possible explanation is different migration selection processes for immigrants who arrive at different ages. Older immigrants in our sample, for example, may have been more likely to immigrate to join family members in the US rather than to find employment, and therefore may be a less select group with respect to health.[51] Another possibility is that because MESA excluded people with clinical cardiovascular disease from the MESA sample, older participants may have been more uniformly healthy, and therefore more similar to each other in terms of cardiovascular risk, regardless of nativity or time in the US.

A limitation of this study was that we could not robustly estimate modification of the associations by race, ethnicity, or region of origin because of sample size limitations.[10,20,39] However, sensitivity analyses of the subpopulations in our sample including the most foreign-born participants (Chinese and Hispanic) produced consistent results. We were also not able to examine incidence of different cardiovascular events separately.[40,41] We were not able to capture information about repeat or circular migration, as the baseline years in US measure among immigrants was based on a single question asking foreign-born participants how many years they had lived in the US. Different participants may have interpreted this question differently, such as reporting the total years encompassed in multiple periods or as the years since they most recently entered the country.[52] The MESA sample was not designed to be representative of the US population and, because of the inclusion requirement of being free of clinical cardiovascular disease at baseline, older participants in particular tend to be healthier than the general population. Our results are also not generalizable to non-Chinese Asian populations, since all participants of Asian descent in MESA are Chinese. Finally, we cannot know the relative contributions to the better cardiovascular health we observed among the foreign-born of lower population cardiovascular risk in sending countries, health selection of immigrants, or conditions within the US. The graded longitudinal results we observed by length of US residence among the foreign-born suggest that differences may not be solely driven health selection, but different selection processes by age or time period may also have contributed to these results.

The faster declines we observed in cardiovascular health among new immigrants suggest that processes associated with moving to and living in the US may contribute to their cardiovascular risk, and warrant further examination. Future research is needed to hone in on the behavioral, psychosocial, and structural mechanisms driving these processes. Understanding these mechanisms may also help explain differences between race/ethnicity groups, such the poorer cardiovascular health we observed among Hispanic compared to Chinese participants. Understanding immigrant patterns of health may help us identify causes of cardiovascular health and risk in the US. In the meantime, public health prevention efforts targeting new immigrants may help slow the deterioration of cardiovascular health and reduce future cardiovascular risk among foreign-born residents.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations

BMI	Body mass index
CV	Cardiovascular
CVH	Cardiovascular health
HR	Hazard ratio
IPAW	Inverse-probability-of-attrition weight
MESA	Multi-Ethnic Study of Atherosclerosis
US	United States of America

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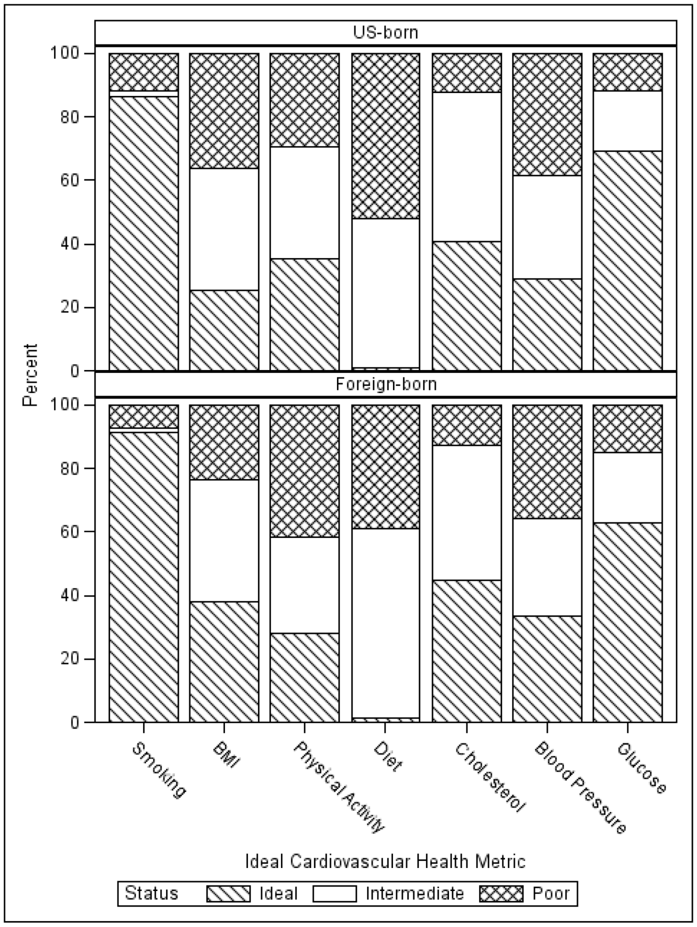

Figure 1.

Distributions of Ideal Cardiovascular Health score metrics by nativity, Multi-Ethnic Study of Atherosclerosis, 2000–2012

BMI = body mass index

Based on pooled observations from the longitudinal analysis sample. For smoking, poor = current smoker; intermediate = former smoker, quit < 12 months ago; ideal = never smoker or former smoker who quit ≥ 12 months ago. For BMI, poor = ≥ 30 kg/m2; intermediate = 25–29.9 kg/m2; ideal = < 25 kg/m^2. For physical activity, categories correspond to tertiles of minutes/week of moderate activity, with vigorous activity minutes double counted. For diet, poor = 0–1 component; intermediate = 2–3 components; ideal = 4–5 components. Healthy diet components are (1) ≥ 4.5 servings of fruit or vegetables per day, (2) ≥ 2 servings of fish per week, (3) ≥ 3 servings of whole grains per day, (4) < 1500 mg sodium per day, and (5) < 3 servings of sugar-sweetened beverages per week. For cholesterol, poor = untreated with ≥ 240 mg/dL or treated with ≥ 200 mg/dL; intermediate =untreated with 200–239 mg/dL or treated with < 200 mg/dL; ideal = < 200 and untreated. For blood pressure, poor = untreated with systolic blood pressure (SBP) ≥ 140 mm Hg or diastolic blood pressure (DBP) ≥ 90 mm Hg or treated with SBP ≥ 120 mm Hg or DBP ≥ 80 mm Hg; intermediate = untreated with SBP 120–139 mm Hg or DBP 80–90 mm Hg or treated with SBP < 120 mm Hg and DBP < 80 mm Hg; ideal = untreated with SBP < 120 mm Hg and DBP < 80 mm Hg. For glucose, categories are based on fasting blood glucose: poor = untreated with ≥ 126 mg/dL or treated with ≥ 100 mg/dL; intermediate = untreated with 100–125 mg/dL or treated with < 100 mg/dL; ideal = untreated with < 100 mg/dL.

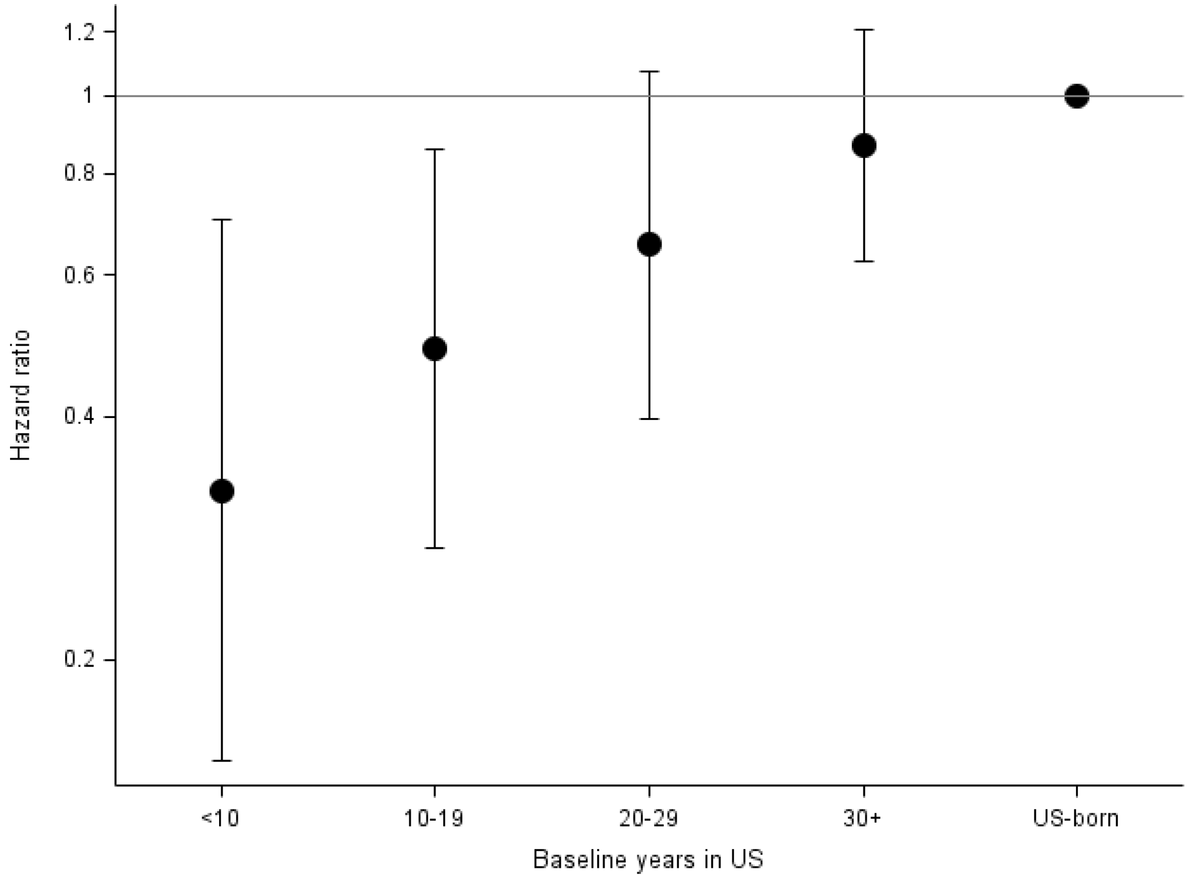

Figure 2.
Adjusted hazard ratios of a cardiovascular event by category of baseline time in US, Multi-Ethnic Study of Atherosclerosis, 2000–2012
Cardiovascular events include myocardial infarction, resuscitated cardiac arrest, angina (definite, or probable if followed by revascularization), stroke, or death attributed to stroke, coronary heart disease, or another atherosclerotic or cardiovascular disease cause. Model uses age as time scale and is adjusted for sex, race/ethnicity, education, and study site.

Table 1

Definitions of ideal, intermediate, and poor status for ideal cardiovascular health score

Metric	Status		
	Ideal	**Intermediate**	**Poor**
Smoking	Never smoker; or former smoker, quit ≥ 12 months ago	Former smoker, quit < 12 months ago	Current smoker
Body Mass Index	< 25 kg/m^2	25–29.9 kg/m^2	≥ 30 kg/m^2
Healthy Diet[a]	0–1 component	2–3 components	4–5 components
Physical Activity[b]	Highest tertile	Middle tertile	Lowest tertile
Total Cholesterol	< 200 mg/dL and untreated	Untreated with 200–239 mg/dL; or treated with < 200 mg/dL	Untreated with ≥ 240 mg/dL; or treated with ≥ 200 mg/dL
Blood Pressure	Untreated with SBP < 120 mm Hg and DBP < 80 mm Hg	Untreated with SBP 120–139 mm Hg or DBP 80–90 mm Hg; or treated with SBP < 120 mm Hg and DBP < 80 mm Hg	Untreated with SBP ≥ 140 mm Hg or DBP ≥ 90 mm Hg; or treated with SBP ≥ 120 mm Hg or DBP ≥ 80 mm Hg
Fasting Blood Glucose	Untreated with < 100 mg/dL	Untreated with 100–125 mg/dL; or treated with < 100 mg/dL	Untreated with ≥ 126 mg/dL; or treated with ≥ 100 mg/dL

SBP = systolic blood pressure; DBP = diastolic blood pressure

[a]Healthy diet components are (1) ≥ 4.5 servings of fruit or vegetables per day, (2) ≥ 2 servings of fish per week, (3) ≥ 3 servings of whole grains per day, (4) < 1500 mg sodium per day, and (5) < 3 servings of sugar-sweetened beverages per week.

[b]Tertiles are based on minutes per week of moderate physical activity + (2 × minutes per week of vigorous physical activity). Tertile 1 = 0-655; tertile 2 = 660-1585; tertile 3 = 1590-32,475. There is known overreporting of physical activity in MESA.

Table 2

Baseline characteristics, Ideal Cardiovascular Health score, and cardiovascular event incidence by category of baseline years lived in the US

		Baseline years in US					
	Total	**< 10**	**10–19**	**20–29**	**≥ 30**	**US-born**	
	N = 6353	**N = 261**	**N = 398**	**N = 420**	**N = 778**	**N = 4496**	
	N (%)	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**p[a]**
Sex							.67
Female	3373 (53)	148 (57)	215 (54)	219 (52)	422 (54)	2369 (53)	
Male	2980 (47)	113 (43)	183 (46)	201 (48)	356 (46)	2127 (47)	
Race/ethnicity							< .001
Non-Hispanic White	2530 (40)	5 (2)	15 (4)	12 (3)	100 (13)	2398 (53)	
Non-Hispanic Black	1732 (27)	5 (2)	20 (5)	41 (10)	57 (7)	1609 (36)	
Chinese	747 (12)	143 (55)	243 (61)	189 (45)	142 (18)	30 (1)	
Mexican	742 (12)	62 (24)	42 (11)	77 (18)	163 (21)	398 (9)	
Non-Mexican Hispanic	602 (9)	46 (18)	78 (20)	101 (24)	316 (41)	61 (1)	
Study site							< .001
Los Angeles, CA	1260 (20)	160 (61)	227 (57)	205 (49)	225 (29)	443 (10)	
Chicago, IL	1102 (17)	26 (10)	72 (18)	75 (18)	136 (17)	793 (18)	
Baltimore, MD	1003 (16)	0 (0)	4 (1)	4 (1)	19 (2)	976 (22)	
St. Paul, MN	997 (16)	48 (18)	33 (8)	30 (7)	68 (9)	818 (18)	
Forsyth County, NC	1023 (16)	0 (0)	3 (1)	0 (0)	13 (2)	1007 (22)	
New York, NY	968 (15)	27 (10)	59 (15)	106 (25)	317 (41)	459 (10)	
	Mean	Mean	Mean	Mean	Mean	Mean	p[b]
Age (years)	62.2	60.7	60.8	58.7	64.3	62.3	< .001
Education (years)	13.1	10.3	10.9	10.5	11.2	14.1	< .001
Ideal Cardiovascular Health score[b]	8.03	8.62	8.60	8.45	7.86	7.95	< .001
	Rate	Rate	Rate	Rate	Rate	Rate	p[c]
Cardiovascular event incidence[c]	10.5	4.1	6.0	9.6	10.1	12.1	< .001

[a]From chi-square test.

[b]Range 0–14. Based on pooled observations from longitudinal analysis sample. P-value is from ANOVA.

[c]Incidence per 1000 person-years. Based on survival analysis sample of N = 6515 participants. Exposure category rates are standardized to the sample age distribution. P-value is from chi-square test based on observed rates and mean follow-up time.

Table 3

Adjusted mean ideal cardiovascular health score, Multi-Ethnic Study of Atherosclerosis, 2000–2012

	Baseline score[a]			10-year change in score		
Baseline years in US	**Mean**	**95% CI**		**Mean**	**95% CI**	
Total sample (N = 6446)[b]						
US-born	7.86	(7.76, 7.97)		−0.47	(−0.52, −0.42)	
≥ 30	8.08	(7.93, 8.23)	*	−0.63	(−0.75, −0.51)	*
20–29	8.46	(8.26, 8.67)	*	−0.76	(−0.92, −0.59)	*
10–19	8.48	(8.27, 8.70)	*	−0.65	(−0.82, −0.48)	*
< 10	8.67	(8.42, 8.92)	*	−1.04	(−1.27, −0.80)	*
IPAW sample (N = 6402)[b,c]						
US-born	7.87	(7.83, 7.95)		−0.46	(−0.52, −0.39	
≥ 30	8.08	(7.95, 8.21)	*	−0.61	(−0.77, −0.45)	
20–29	8.46	(8.30, 8.62)	*	−0.75	(−0.98, −0.53)	*
10–19	8.46	(8.29, 8.63)	*	−0.65	(−0.90, −0.40)	
< 10	8.67	(8.46, 8.88)	*	−1.07	(−1.41, −0.73)	*
Chinese participants only (N = 745)[d]						
US-born	8.55	(7.93, 9.17)		−0.39	(−0.96, 0.19)	
≥ 30	8.98	(8.68, 9.28)		−0.66	(−0.91, −0.41)	
20–29	8.85	(8.58, 9.12)		−0.72	(−0.96, −0.49)	
10–19	8.85	(8.59, 9.11)		−0.64	(−0.85, −0.44)	
< 10	9.30	(8.99, 9.62)	*	−1.06	(−1.35, −0.76)	*
Hispanic participants only (N = 1341)[d]						
US-born	7.40	(7.16, 7.63)		−0.56	(−0.72, −0.39)	
≥ 30	7.51	(7.31, 7.71)		−0.54	(−0.70, −0.38)	
20–29	7.88	(7.57, 8.19)	*	−0.64	(−0.90, −0.38)	
10–19	8.21	(7.84, 8.58)	*	−0.89	(−1.21, −0.56)	
< 10	8.03	(7.64, 8.42)	*	−0.99	(−1.40, −0.58)	
Baseline age < 65 (N = 3609)[b]						
US-born	8.15	(8.01, 8.30)		−0.51	(−0.58, −0.45)	
≥ 30	8.36	(8.14, 8.57)		−0.77	(−0.93, −0.61)	*
20–29	8.92	(8.67, 9.16)	*	−0.84	(−1.03, −0.65)	*
10–19	8.94	(8.66, 9.22)	*	−0.76	(−0.97, −0.56)	*
< 10	9.02	(8.69, 9.36)	*	−1.11	(−1.41, −0.82)	*
Baseline age 65+ (N = 2837)[b]						

	Baseline score[a]			10-year change in score		
Baseline years in US	**Mean**	**95% CI**		**Mean**	**95% CI**	
US-born	7.70	(7.55, 7.86)		−0.38	(−0.46, −0.31)	
≥ 30	7.89	(7.69, 8.10)		−0.45	(−0.63, −0.27)	
20–29	7.76	(7.40, 8.11)		−0.53	(−0.85, −0.20)	
10–19	7.92	(7.59, 8.26)		−0.44	(−0.72, −0.16)	
< 10	8.27	(7.88, 8.66)	*	−0.90	(−1.30, −0.49)	*

IPAW = inverse-probability-of-attrition-weighted; US = United States of America

* p < .05 for difference from US-born.

[a] Possible and observed range 0–14. Higher score denotes better cardiovascular health.

[b] Adjusted for sex, baseline age and age squared (centered at population mean of 61), race/ethnicity (non-Hispanic white, non-Hispanic black, Chinese, Mexican, other Hispanic), education (centered at 12 years), and study site. Table values are calculated at population mean values of covariates.

[c] Sample is smaller because of missingness in variables used to construct weights. Confidence intervals are bootstrapped.

[d] Adjusted for sex, baseline age and age squared (centered at population mean of 61), education (centered at 12 years), and study site. Hispanic participant model is adjusted for Mexican vs. other Hispanic background. Table values are calculated at population mean values of covariates.

Table 4

Adjusted hazard ratios of any cardiovascular event per category of baseline years in US[a,b], Multi-Ethnic Study of Atherosclerosis, 2000–2012

	HR	95% CI
Total sample (N = 6515; No. events = 624)[c]	1.29	(1.12, 1.49)
IPAW sample (N = 6257; No. events = 592)[c,d]	1.26	(1.05, 1.52)
Chinese participants only (N = 746; No. events = 43)[e]	1.45	(1.08, 1.94)
Hispanic participants only (N = 1363; No. events = 131)[e]	1.16	(0.95, 1.43)
Baseline age < 65 (N = 3637; No. events = 212)[c]	1.48	(1.15, 1.90)
Baseline age 65+ (N = 2878; No. events = 412)[c]	1.19	(0.99, 1.42)

US = United States of America; IPAW = inverse-probability-of-attrition-weighted

[a]Cardiovascular events include myocardial infarction, resuscitated cardiac arrest, angina (definite, or probable if followed by revascularization), stroke, or death attributed to stroke, coronary heart disease, or another atherosclerotic or cardiovascular disease cause. Models use age as time scale.

[b]Categories entered into model as a single ordinal variable: 1 = < 10 years, 2 = 10-19 years, 3 = 20-29 years, 4 = 30+ years, 5 = U.S.-born. This choice was made based on the functional form of the association in models using separate indicators for each category (see Figure 2).

[c]Adjusted for sex, race/ethnicity (non-Hispanic white, non-Hispanic black, Chinese, Mexican, other Hispanic), education (centered at 12 years), and study site.

[d]Sample is smaller because of missingness in variables used to construct weights. Confidence intervals are bootstrapped.

[e]Adjusted for sex, education (centered at 12 years), and study site. Hispanic participant model is adjusted for Mexican vs. other Hispanic background.