ORIGINAL INVESTIGATION

Incarceration, Incident Hypertension, and Access to Health Care

Findings From the Coronary Artery Risk Development in Young Adults (CARDIA) Study

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Background: Incarceration is associated with increased cardiovascular disease mortality, but prospective studies exploring mechanisms of this association are lacking.

Methods: We examined the independent association of prior incarceration with incident hypertension, diabetes, and dyslipidemia using the Coronary Artery Risk Development in Young Adults (CARDIA) study—a cohort of young adults aged 18 to 30 years at enrollment in 1985-1986, balanced by sex, race (black and white), and education (high school education or less). We also examined the association of incarceration with left ventricular hypertrophy on echocardiography and with barriers to health care access.

Results: Of 4350 participants, 288 (7%) reported previous incarceration. Incident hypertension in young adulthood was more common among former inmates than in those without incarceration history (12% vs 7%; odds ratio, 1.7 [95% confidence interval {CI}, 1.2-2.6]), and this association persisted after adjustment for smoking, alcohol and illicit drug use, and family income (adjusted odds ratio [AOR], 1.6 [95% CI, 1.0-2.6]). Incarceration was significantly associated with incident hypertension in those groups with the highest prevalence of prior incarceration, ie, black men (AOR, 1.9 [95% CI, 1.1-3.5]) and less-educated participants (AOR, 4.0 [95% CI, 1.0-17.3]). Former inmates were more likely to have left ventricular hypertrophy (AOR, 2.7, [95% CI, 0.9-7.9]) and to report no regular source for medical care (AOR, 2.5, [95% CI, 1.3-4.8]). Cholesterol levels and diabetes rates did not differ by history of incarceration.

Conclusions: Incarceration is associated with future hypertension and left ventricular hypertrophy among young adults. Identification and treatment of hypertension may be important in reducing cardiovascular disease risk among formerly incarcerated individuals.

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INCARCERATION HAS BECOME INcreasingly frequent in the lives of young adults. Between 1987 and 2007, the US prison population tripled, such that currently 1 in 30 men between the ages of 20 and 34 is behind bars and 1 in 9 black men in this age group is incarcerated.[1] This rise in incarceration as a normative experience for young men and young black men in particular makes it especially important to understand the implications of incarceration on future health status.

While the health and health care of prisoners has received some attention, little is known about the health status of those with a history of incarceration. One large study of recently released prisoners from Washington State demonstrated an increased risk of death immediately following their release from prison.[2] The second most common cause of death was from cardiovascular disease (CVD), although the mechanisms of this increased risk were not examined in this study.

Increases in CVD risk factors associated with incarceration may explain part of the increased risk of heart disease in prisoners,[3] but to our knowledge, no prospective study to date has directly measured such risk factors in either current or former US inmates. The Coronary Artery Risk Development in Young Adults (CARDIA) cohort provides the unique opportunity to explore the development of CVD risk in young adults with a history of incarceration. The objectives of this study were to examine prospectively whether a history of incarceration is associated with the development of CVD risk factors, to explore possible mechanisms and outcomes of this association, and to examine access to health care among those with prior incarceration.

METHODS

SAMPLE AND SETTING

The CARDIA study is a longitudinal investigation of CVD risk factors and subclinical coronary disease in a population of black and white men and women aged 18 to 30 years at baseline in 1985-1986; it is described in detail in previous publications.[4] At baseline, the study enrolled 5115 young adults, who were recruited from 4 US cities (Birmingham, Alabama; Chicago, Illinois; Minneapolis, Minnesota; and Oakland, California). The sampling strategy resulted in a cohort balanced by race (52% black and 48% white), sex (55% male and 45% female), age (45% aged 18-24 years and 55% aged 25-30 years), and education level (40% with ≤12 years and 60% with >12 years.) Subsequent re-examinations have taken place at years 2 (1987-1988), 5 (1990-1991), 7 (1992-1993), 10 (1995-1996), 15 (2000-2001), and 20 (2005-2006), with high retention rates (91% at year 2, 86% at year 5, 81% at year 7, 79% at year 10, 73% at year 15, and 69% at year 20.) Of the 5115 participants in the CARDIA study, only those who had complete baseline data and follow-up through the year 5 examination were included in the primary analysis (N=4350).

HISTORY OF INCARCERATION

To assess history of incarceration, participants at baseline (1985-1986) and year 2 (1987-1988) were asked the following question: "During the past year, did any of the following happen to you?" and "Went to jail" was one of the prespecified responses. In year 2, participants could report any incarceration event occurring since the prior examination. Responses to these 2 items permitted us to develop an incarceration exposure variable reflecting any jail time during a 3-year period of young adulthood, extending from 1 year prior to study entry through the 2 years preceding the year 2 examination. Since most jail experiences occur during early adult years,[1] this measure offers a strong indicator of incarceration in young adulthood.

CVD RISK FACTORS

Cardiovascular disease risk factors were measured at the year 5 examination (1990-1991). Trained and certified technicians used a random zero sphygmomanometer to record participants' blood pressure at the year 5 examination and all subsequent CARDIA study examinations. Measurements of systolic and diastolic blood pressure were taken 3 times at 1-minute intervals. For the purposes of this analysis, we used a mean of the second and third blood pressure measurement. Hypertension was defined by a systolic blood pressure of 140 mm Hg or higher, diastolic blood pressure of 90 mm Hg or higher, or use of antihypertensive medication. Incident hypertension was defined as meeting these criteria by the year 5 examination in persons without hypertension at baseline. Diabetes was defined by use of antidiabetic medication. Serum total cholesterol and high-density lipoprotein cholesterol levels were measured, and low-density lipoprotein cholesterol level was calculated using the Friedewald equation.

POTENTIAL CONFOUNDERS

Body mass index (BMI) (calculated as weight in kilograms divided by height in meters squared) and smoking history were measured and examined as potential confounders for the association between incarceration and CVD risk factors. Participants were weighed in light clothing using a standard balance beam scale, and height was measured to the nearest 0.5 cm using a wall-mounted stadiometer. Use of cigarettes was ascertained with interviewer-administered questionnaire. For cigarette smoking, participants were categorized as current smokers if they had smoked more than 5 cigarettes per week for the past 3 months and former smokers if they had ever smoked.

Use of cocaine, amphetamines, and excessive alcohol were also ascertained with interviewer-administered questionnaires. For cocaine or amphetamine use, participants were categorized as current users if they had used in the past month, former users if they had ever used but not in the past month, or never users. For alcohol use, participants were categorized as excessive alcohol consumers based on the at-risk consensus thresholds of the National Institute on Alcohol Abuse and Alcoholism, which were met if a man consumed 14 drinks per week or more and a woman consumed more than 7 drinks per week, where a drink was counted as 360 mL of beer, 150 mL of wine, or 45 mL of spirits.[5]

Socioeconomic status of each participant was approximated using a measure of family income at year 5. Participants were asked which category best describes their total combined family income for the past 12 months. This included income from all sources (eg, wages, veteran's benefits, help from relatives, and rent from properties [before taxes]). Those who responded that their family income was less than $ 24 999 were defined as meeting 200% of the federal poverty line and being of low socioeconomic status.[6]

ECHOCARDIOGRAPHY MEASURES

During year 5, all CARDIA study participants underwent 2-dimensional–guided M-mode echocardiography as described previously.[7] Left ventricular mass was measured in grams and indexed to body surface area measured as height in meters squared. We defined left ventricular hypertrophy (LVH) as left ventricular mass index greater than 90 g/m^2.

HEALTH CARE ACCESS

To assess health care access barriers, participants were asked the following 3 questions: (1) "In the past 2 years, have you always had health insurance or other coverage for medical care?"; (2) "Do you have a usual source of care? By that we mean the place you go if you need a checkup or if you are ill"; and (3) "Was there anytime during the past 2 years when you did not seek medical care because it was too expensive or health insurance did not cover it?" Negative answers to question 1 and 2 indicated an insurance barrier and regular care barrier, respectively. An affirmative answer to question 3 was considered an expense barrier.

Realizing that we did not have health care access data at or before year 7 (1992-1993), we could not perform a formal mediation analysis to test whether health care access might explain any associations of incarceration with CVD risk. Instead, we studied potential associations between a history of incarceration and subsequent barriers to health care access. If present, such associations might only intensify the increased CVD risk of those with a history of incarceration.

STATISTICAL ANALYSIS

CARDIA study participants with and without a history of incarceration in the 3-year exposure period captured by our data were first compared for baseline sociodemographic characteristics, CVD risk factors, and potential explanatory risk factors of disease using the paired t test and χ^2 test as appropriate. The primary analyses examined the association of incarceration his-

tory in the first 3 years of the CARDIA study and CVD risk factors at the year 5 examination, as well as the incidence of these risk factors by year 5. We chose year 5 for an assessment of these outcomes because of the difficulty in postulating the mechanisms whereby incarceration may contribute to hypertension further in the future.

We next examined the independent association between incarceration and the incidence of these risk factors using multivariable logistic regression and explored covariates of the associations using staged models, first accounting for demographics, clinical risk factors, and behavioral risk factors (illicit drug use and excessive alcohol consumption) and then adding a measure of socioeconomic status. $P<.05$ was considered statistically significant. Because those incarcerated were mostly male, black, and with limited education (and because these were sampling strata within the original CARDIA study design), we repeated our analyses within subgroups defined by sex, race, and education and tested for interactions between incarceration and these factors. Because of differential dropout across these strata, we also ran models using inverse probability-of-censoring weights to reduce bias potentially resulting from differential dropout.[8]

In secondary analyses, we examined whether measures of left ventricular mass index and LVH differed by prior incarceration using Fisher exact, *t*, and χ^2 tests as appropriate and multivariable logistic regression models. Finally, among persons with hypertension evident by year 5, we investigated the association between incarceration and barriers to health care access in year 7 using multivariable logistic regression.

RESULTS

Of the 4350 participants included in this analysis, 288 (7%) reported having been incarcerated during the 3-year period of young adulthood captured in the first 2 surveys. Black men and less-educated participants were most likely to have a history of prior incarceration (**Table 1**). Within these subgroups, former inmates were more likely to report family earnings below 200% of the federal poverty line, smoking, illicit drug use, and excess alcohol consumption compared with those without incarceration history.

By the year 5 examination, persons with incarceration history had higher mean systolic blood pressures and were more likely to have hypertension (**Table 2**). Among participants without hypertension at baseline, former inmates were more likely to have developed incident hypertension by the year 5 examination than the participants without history of incarceration (12% vs 7%; unadjusted odds ratio [OR], 1.7 [95% confidence interval {CI}, 1.2-2.6]). Among black men and less-educated individuals, subgroups of the CARDIA study sample in whom incarceration was more common, the relationship between incarceration and hypertension was particularly pronounced and statistically significant. Cholesterol levels (low-density lipoprotein cholesterol, 108 mg/dL vs 108 mg/dL [to convert cholesterol to millimoles per liter, multiply by 0.0259] [$P=.93$]; high-density lipoprotein cholesterol, 53 mg/dL vs 53 mg/dL [$P=.44$]) and diabetes (2% vs 3% [$P=.81$]) did not differ between participants with and without a history of incarceration, respectively, even in subgroup analyses.

Because of the association of incarceration with hypertension, we examined several potential explanatory factors for the observed association of prior incarceration and incident hypertension. Adjustment for age, sex, race, and drugs and alcohol use did not alter this association (adjusted OR [AOR], 1.6 [95% CI, 1.0-2.5]), nor did additional adjustment for poverty (AOR, 1.6 [95% CI, 1.0-2.6]). Although the statistical tests for interaction between incarceration and race, sex, and education were not significant, we ran these models within the sampling strata of the CARDIA study (**Figure**). Subgroups with the highest rate of incarceration—black men and less-educated participants—showed significant associations between incarceration and incident hypertension in adjusted models; associations in subgroups that had lower rates of incarceration were not significant but had wide confidence intervals. Although black men and less-educated individuals were more likely to have been lost to follow-up by year 5, our results were no different in analyses using inverse probability weights to reduce bias due to differential dropout (AOR for all participants, 1.5 [95% CI, 0.9-2.2]; black men, 1.9 [95% CI, 1.0-3.6]; and less-educated participants, 1.6 [95% CI, 0.9-2.7]).

We examined whether incarceration might be associated with end-organ damage related to hypertension. Persons with incarceration history had higher mean (SD) left ventricular mass index (54.0 [14.1] g/m^2 vs 50.3 [12.9] g/m^2 [$P<.001$]) and were more likely to have LVH (2% vs 0.6% [$P=.005$]). Prior incarceration was associated with LVH in unadjusted analyses, and we observed a trend for an association even after accounting for potential confounders (**Table 3**). In analyses restricted to black men and less-educated individuals, prior incarceration was also associated with LVH in both unadjusted and adjusted models.

Among participants with hypertension at the year 5 examination, those with a history of incarceration had an increased odds of reporting a barrier to health care at the next follow-up visit 2 years later (**Table 4**). This association persisted after adjustment for age, race, sex, and socioeconomic status and was more pronounced in black and less-educated participants. Former inmates were also more likely to lack treatment for their hypertension at the year 7 examination (17% [former inmates] vs 41% [no prior incarceration] treated; unadjusted OR, 3.3 [95% CI, 1.3-9.1]) and in each of the follow-up visits during the entire 20-year duration of the CARDIA study (unadjusted OR at year 20, 2.0 [95% CI, 1.3-3.0]). Incarceration prior to 1987 was associated with a 5.7–mm Hg higher mean systolic blood pressure at the year 20 examination (95% CI, 0.2-11.2 mm Hg), but not a higher diastolic blood pressure at year 20 (1.1 mm Hg [95% CI, –0.6 to 2.8 mm Hg]) in analyses adjusting for the age, sex, and race of these participants.

COMMENT

In a well-characterized US cohort of black and white young adults, we found that a history of incarceration is associated with a significantly elevated risk of future hypertension and with LVH. During the 3- to 5-year period that followed incarceration, we found a cumulative incidence of hypertension of 12% among these young adults aged 23 to 35 years, compared with 7% among those with-

Table 1. Sociodemographic and Clinical Characteristics of 4350 Black and White Men and Women by History of Incarceration Before 1987[a]

Characteristic	Prior Incarceration	No Prior Incarceration	*P* Value
All participants (N = 4350)	288 (7)	4062 (93)	
Age, mean (SD), y	24.0 (3.7)	25.1 (3.6)	<.001
Income <200% federal poverty line	173 (60)	1462 (36)	<.001
BMI, mean (SD)	26 (5)	26 (6)	.59
Tobacco use (current or former)	182 (63)	1269 (31)	<.001
Cocaine use (current or former)	153 (55)	1386 (35)	<.001
Amphetamine use (current or former)	86 (30)	1030 (26)	.05
Alcohol use (excessive)	99 (34)	549 (13)	<.001
Black men (n = 905)	154 (53)	751 (18)	
Age, mean (SD), y	23.8 (0.3)	24.4 (0.1)	.08
Income <200% federal poverty line	104 (68)	317 (43)	<.001
BMI, mean (SD)	25.8 (0.4)	26.6 (0.2)	.12
Tobacco use (current or former)	98 (64)	288 (39)	<.001
Cocaine use (current or former)	83 (55)	224 (30)	<.001
Amphetamine use (current or former)	33 (22)	99 (13)	.008
Alcohol use (excessive)	67 (50)	171 (28)	<.001
White men (n = 1054)	62 (22)	992 (24)	
Age, mean (SD), y	24.2 (0.5)	25.6 (0.1)	.002
Income <200% federal poverty line	25 (40)	263 (27)	.02
BMI, mean (SD)	25.1 (0.6)	25.6 (0.1)	.37
Tobacco use (current or former)	39 (63)	296 (30)	<.001
Cocaine use (current or former)	39 (63)	448 (45)	<.001
Amphetamine use (current or former	34 (55)	377 (38)	.03
Alcohol use (excessive)	23 (40)	210 (23)	.004
Black women (n = 1214)	49 (17)	1165 (29)	
Age, mean (SD), y	23.9 (0.5)	24.5 (0.1)	.27
Income <200% federal poverty line	32 (67)	589 (51)	.03
BMI, mean (SD)	27.7 (1.1)	28.1 (0.2)	.66
Tobacco use (current or former)	38 (78)	388 (33)	<.001
Cocaine use (current or former)	21 (44)	238 (21)	<.001
Amphetamine use (current or former)	6 (12)	125 (11)	.74
Alcohol use (excessive)	8 (19)	8 (1)	.03
White women (n = 1177)	23 (8)	1154 (28)	
Age, mean (SD), y	24.7 (0.8)	25.6 (0.1)	.004
Income <200% federal poverty line	12 (52)	293 (25)	.45
BMI, mean (SD)	25.4 (1.0)	24.3 (0.2)	.36
Tobacco use (current or former)	7 (30)	297 (26)	.61
Cocaine use (current or former)	13 (57)	472 (41)	.24
Amphetamine use (current or former)	13 (57)	429 (38)	<.001
Alcohol use (excessive)	1 (5)	94 (9)	.63
≤High school education (n = 1640)	182 (63)	1458 (36)	
Age, mean (SD), y	23.3 (0.3)	24.1 (0.1)	.02
Male	144 (79)	625 (43)	<.001
Black	137 (75)	913 (63)	.001
Income <200% federal poverty line	121 (67)	784 (54)	.001
BMI, mean (SD)	25.8 (0.4)	26.8 (0.2)	.05
Tobacco use (current or former)	129 (71)	660 (45)	<.001
Cocaine use (current or former)	96 (54)	477 (33)	<.001
Amphetamine use (current or former)	49 (27)	336 (23)	.29
Alcohol use (excessive)	72 (45)	256 (22)	<.001
>High school (n = 2710)	106 (37)	2604 (64)	
Age, mean (SD), y	25.1 (0.3)	25.6 (0.1)	.11
Male	72 (68)	1118 (43)	<.001
Black	66 (13)	1003 (39)	<.001
Income below 200% federal poverty line	52 (49)	678 (26)	<.001
BMI, mean (SD)	26.3 (0.6)	25.8 (0.1)	.37
Tobacco use (current or former)	53 (50)	609 (23)	<.001
Cocaine use (current or former)	60 (57)	909 (35)	<.001
Amphetamine use (current or former)	37 (35)	694 (27)	.10
Alcohol use (excessive)	27 (30)	293 (13)	<.001

Abbreviation: BMI body mass index (calculated as weight in kilograms divided by height in meters squared).

[a]Data are given as number (percentage) of participants unless otherwise indicated. Percentages are column percentages; for each covariate, the percentages indicate percentages within strata.

Table 2. Blood Pressure and Hypertension Among the CARDIA Study Cohort in 1990-1991 at Age 23 to 35 Years by History of Incarceration Before 1987

	Prior Incarceration	No Prior Incarceration	*P* Value
All participants (N = 4350)			
SBP, mean (SD), mm Hg	111 (13)	108 (11)	<.001
DBP, mean (SD), mm Hg	70 (11)	69 (10)	.42
Hypertension, No. (%)	65 (23)	650 (16)	.006
Incident hypertension, No. (%)[a]	29 (12)	254 (7)	.007
Black men (n = 905)			
SBP, mean (SD), mm Hg	114 (12)	114 (11)	.73
DBP, mean (SD), mm Hg	71 (11)	73 (10)	.10
Hypertension, No. (%)	43 (23)	155 (20)	.05
Incident hypertension, No. (%)[a]	22 (17)	75 (11)	.08
White men (n = 1054)			
SBP, mean (SD), mm Hg	111 (12)	110 (11)	.57
DBP, mean (SD), mm Hg	70 (10)	71 (9)	.33
Hypertension, No. (%)	10 (16)	149 (15)	.81
Incident hypertension, No. (%)[a]	4 (7)	39 (4)	.35
Black women (n = 1214)			
SBP, mean (SD), mm Hg	106 (14)	107 (11)	.39
DBP, mean (SD), mm Hg	67 (13)	69 (10)	.09
Hypertension, No. (%)	8 (16)	235 (20)	.51
Incident hypertension, No. (%)[a]	2 (5)	96 (9)	.29
White women (n = 1177)			
SBP, mean (SD), mm Hg	102 (10)	101 (10)	<.001
DBP, mean (SD), mm Hg	67 (13)	65 (8)	.42
Hypertension, No. (%)	4 (17)	123 (10)	.30
Incident hypertension, No. (%)[a]	1 (5)	44 (7)	.84
≤High school education (n = 1640)			
SBP, mean (SD), mm Hg	111 (12)	109 (12)	.01
DBP mean (SD), mm Hg	70 (12)	70 (10)	.84
Hypertension, No. (%)	46 (25)	279 (19)	.05
Incident hypertension, No. (%)[a]	22 (14)	111 (9)	.02
>High school education (n = 2710)			
SBP, mean (SD), mm Hg	110 (13)	107 (11)	.006
DBP, mean (SD), mm Hg	70 (12)	69 (10)	.49
Hypertension, No. (%)	19 (18)	383 (14)	.83
Incident hypertension, No. (%)[a]	7 (7)	143 (6)	.58

Abbreviations: CARDIA, Coronary Artery Risk Development in Young Adults; DBP, diastolic blood pressure; SBP, systolic blood pressure.

[a] A total of 458 participants with baseline hypertension were excluded from this analysis (n = 3892).

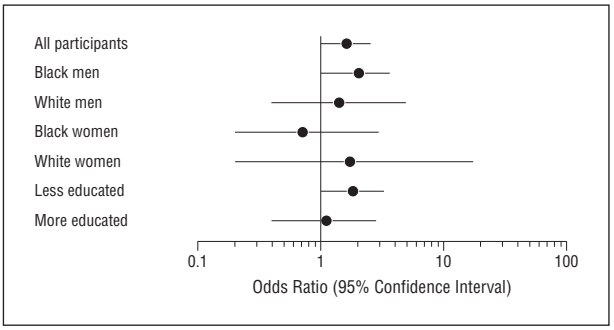

Figure. Association of incarceration history before 1987 with subsequent incident hypertension (1990-1991) at age 23 to 35 years. Odds ratios were adjusted for traditional clinical risk factors for hypertension including body mass index, smoking, excessive alcohol consumption, and illicit drug use, including cocaine and amphetamine use. The areas under the curve for the models including all participants ranged from 0.52 to 0.68. The interaction terms between incarceration and race (*P*=.77), incarceration and sex (*P*=.15), and incarceration and educational level (*P*=.22) were not statistically significant.

out a history of incarceration. This association was strongest in those groups most likely to be incarcerated—black men and those with limited education—and was independent of alcohol and illicit drug use. Prior incarceration was also significantly associated with future barriers to health care access. Improving access to health care among former inmates as well as screening for hypertension and other modifiable hypertension risk factors may be important in reducing the risk of CVD death among individuals with a history of incarceration.

The mechanisms by which incarceration may lead to hypertension are not known. Several mechanisms have been postulated in prior studies, including higher use of drugs and alcohol, increased obesity, or lower socioeconomic status.[9-12] Our data suggest that these mechanisms do not entirely explain the hypertension risk among former inmates, since we observed a significant residual effect even after accounting for these factors. Other possible explanations include increased hostility or stress among individuals with prior incarceration that has been shown to increase the risk for hypertension and ultimately atherosclerosis.[13-15] The stress of incarceration may increase catecholamine or stress hormone levels that lead to hypertension, or incarceration may cause lasting dysregulation of these hormones that might lead to the development of hypertension later in life at faster rates.

Although exploring these mechanisms whereby incarceration may contribute to hypertension is beyond the scope of the present study, our results suggest that hypertension and associated LVH in young former inmates may contribute to the previously observed increased risk of CVD death after their release. Left ventricular hypertrophy is a well-established independent risk factor for the development of heart failure and mortality.[16,17] Further study is needed to explore this relationship between incarceration, hypertension, and LVH, both to establish whether the association is causal—and if so, to elucidate how a history of incarceration might lead to hypertension and cardiovascular damage—and whether this is related to the type and duration of incarceration exposure.

While incarceration is not a traditional risk factor for CVD, our results suggest that a history of incarceration should be understood as part of the risk profile for the development of hypertension and LVH in young adults. Physicians working in communities where incarceration is highly prevalent should consider screening for a history of incarceration because it may provide information about the future risk of hypertension and associated end-organ damage, as well as the risk of discontinuity in health care or medical treatment. Moreover, detention in jail, where health care is constitutionally guaranteed, may present a prime opportunity to screen soon-to-be released inmates for hypertension and to link inmates with chronic conditions to health care services in the community on release.

We find that hypertensive individuals with a history of incarceration were less likely to have insurance, ac-

Table 3. Association of Incarceration History Before 1987 With Left Ventricular Hypertrophy in 1990-1991 at Age 23 to 35 Years[a]

Participants	Unadjusted		Adjusted for Demographic Characteristics, Clinical Risk Factors, and Illicit Drug Use[b]		Adjusted for Demographic Characteristics, Clinical Risk Factors, Illicit Drug Use, and Socioeconomic Status[c]	
	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
All participants (n=3688)	3.8 (1.4-10.1)	.009	2.5 (0.8-7.3)	.14	2.7 (0.9-7.9)	.08
Black men (n=760)	2.6 (0.6-10.6)	.18	4.3 (0.9-20.0)	.07	6.0 (1.2-31.0)	.03
Participants with ≤high school education (n=1364)	4.8 (1.6-14.4)	.006	4.3 (1.0-17.3)	.04	4.3 (1.0-17.3)	.04

Abbreviations: CI, confidence interval; OR, odds ratio.
[a]This analysis included only participants who were not hypertensive at baseline. The areas under the curve for models including all participants ranged from 0.69 to 0.82.
[b]Traditional clinical risk factors for hypertension include body mass index, smoking, and excessive alcohol consumption; illicit drug use includes cocaine and amphetamine use.
[c]Socioeconomic status is defined by family income.

Table 4. Association of Incarceration History With Subsequent Access to Care Among the 650 CARDIA Study Participants With Hypertension

Participants	No Regular Source of Care		No Health Insurance		Limited Medical Care	
	AOR (95% CI)[a]	*P* Value	AOR (95% CI)	*P* Value	AOR (95% CI)	*P* Value
All participants (n=650)	2.5 (1.3-4.8)	.005	2.5 (1.4-4.7)	.003	4.3 (2.1-8.7)	<.001
Black men (n=170)	2.9 (1.2-6.6)	.01	2.4 (1.1-5.4)	.03	6.5 (2.2-18.8)	<.001
Participants with ≤high school education (n=287)	2.5 (1.1-5.5)	.03	3.3 (1.5-6.9)	.02	5.1 (2.0-13.2)	<.001

Abbreviations: AOR, adjusted odds ratio; CARDIA, Coronary Artery Risk Development in Young Adults; CI, confidence interval.
[a]Adjusted for sex, race, age, and socioeconomic status.

cess to health care, or be using antihypertensive medications. Current and former inmates with chronic diseases such as hypertension typically fall at the intersection of 2 poorly functioning health care systems: the correctional health care system and the public safety net health care system. Neither health care system is well equipped to take care of the growing population of individuals with chronic medical conditions who cycle in and out of both systems. Ninety percent of those released from jail are uninsured and lack financial resources to pay for their medical care in the community.[18] Most state correctional systems do not provide discharged inmates with a state identification card, thereby rendering such individuals ineligible for care in the major county hospitals that exist to serve indigent persons on release from correctional facilities.[19] With access to regular outpatient care sharply constrained, formerly incarcerated individuals are more likely to seek care in the emergency department rather than a primary care office.[19,20] The resulting discontinuity and irregularity of service may lead to poor health outcomes and/or duplication of services. Improved continuity of care between correctional facilities and the community could protect the health of inmates with hypertension and other chronic conditions, but assuring such continuity would require reconfiguration of correctional services and modest interventions such as the provision of referrals and identification cards to speed re-entry.

There are several limitations in our study. History of incarceration was only measured in the first 2 CARDIA study examinations, and the single binary question item captured the preceding year events that would have included both a brief jail stay after arrest as well as longer periods of imprisonment. Because the CARDIA study questionnaire asked specifically about jail, we can also not exclude the possibility that those in prisons would not have answered affirmatively. We therefore lack accurate information about the duration, frequency, or nature of the incarceration exposure or exposure that might have occurred well before the baseline examination. Such information would be useful for understanding the true effect of the type, frequency, and intensity of incarceration on the development of hypertension, especially given the high rates of recidivism nationwide.[21] Measurement of important confounders in this study, including illicit drug use, was based on self-report. There may have been social desirability and recall bias at play in this study, especially in the reporting of illicit drugs.[22,23] Nonetheless, the prevalence of illicit drug use observed in this study approximates that in other studies in both incarcerated and nonincarcerated populations.[23,24] Finally, we initially chose to examine 3 types of CVD risk factors and only found an association of incarceration with hypertension, thus raising the possibility of type 1 error. However, the strength of this analysis is the consistency of the association we observe across the population subgroups in the United States at highest risk of incarceration, as well as the association of incarceration with the end-organ manifestations of hypertension.

In conclusion, we found that prior incarceration predicts future hypertension and LVH among young adults. For the more than 7 million people that pass through US jails and prisons each year,[25] incarceration may be an independent risk factor for the development of hypertension and LVH, both of which put such persons at higher risk for clinical CVD. Incarceration may be a cause for hypertension and CVD, but may also present an underused opportunity for intervention and improving health and access to health care.

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