Incarceration History and Uncontrolled Blood Pressure in a Multi-Site Cohort

Benjamin A. Howell, MD MPH¹, Jessica B. Long, MPH¹, E. Jennifer Edelman, MD MHS^{1,2}, Kathleen A. McGinnis, DrPH MS³, David Rimland, MD^{4,5}, David A. Fiellin, MD^{1,2}, Amy C. Justice, MD PhD^{1,2,3}, and Emily A. Wang, MD MAS¹

¹Department of Internal Medicine, Yale University School of Medicine, New Haven, CT, USA; ²Center for Interdisciplinary Research on AIDS, Yale University School of Public Health, New Haven, CT, USA; ³Veterans Administration Connecticut Healthcare System, West Haven, CT, USA; ⁴Atlanta VA Medical Center, Atlanta, GA, USA; ⁵Emory University School of Medicine, Atlanta, GA, USA.

BACKGROUND: Incarceration is associated with increased risk of hypertension and cardiovascular disease mortality. We used data from the Veterans Aging Cohort Study (VACS) to explore the impact of incarceration on blood pressure (BP) control.

METHODS: Among hypertensive VACS participants, we measured the association between self-reported recent incarceration or past (not recent) history of incarceration and BP control in the year following the survey. To analyze the association between incarceration and BP control, we used logistic regression models adjusted for sociodemographic characteristics, clinical factors (HIV status and body mass index), and behavioral factors (history of smoking, unhealthy alcohol use, illicit drug use). We explored potential mediators including post-traumatic stress disorder (PTSD), depression, primary care engagement, and adherence to antihypertensive medications.

RESULTS: Among the 3515 eligible VACS participants, 2304 participants met the inclusion criteria. Of these, 163 (7 %) reported recent incarceration, and 904 (39 %) reported a past history of incarceration. Participants with recent or past history of incarceration were more likely to have uncontrolled BP than those without a history of incarceration (67 % vs. 56 % vs. 51 %, $p < 0.001$). In multivariable analysis, recent incarceration (adjusted odds ratio [AOR] = 1.57 95 % confidence interval [CI]: 1.09–2.26), but not a past history of incarceration (AOR = 1.08 95 % CI: 0.90–1.30), was associated with uncontrolled BP compared with those who were never incarcerated.

CONCLUSIONS: Among patients with a history of hypertension, recent incarceration is associated with having uncontrolled BP following release. Interventions are needed for recently released individuals to improve hypertension outcomes.

KEY WORDS: hypertension/epidemiology; hypertension/therapy; prisoners; socioeconomic factors; chronic disease/epidemiology; chronic disease/therapy; incarceration.

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INTRODUCTION

Incarceration rates in the United States have risen exponentially, with 500 % growth since 1970.¹ The US incarcerated population today stands at more than 2.2 million.² At the current rate, 1 in 15 people, and 1 in 3 black men, will be incarcerated in federal or state prisons in their lifetimes.³ People with a history of incarceration have higher rates of chronic medical conditions^{4–7} and risk of death than the general population.^{8–10} Importantly, cardiovascular disease is a leading cause of death among individuals with prior incarceration.^{8, 11, 12}

The association between a history of incarceration and increased risk of cardiovascular disease may be partially explained by an increased prevalence of cardiovascular risk factors in this population, especially hypertension, although the mechanisms are not known.^{6, 7, 13} Effective control of hypertension is a well-studied method of averting serious cardiovascular outcomes, including ischemic heart disease, cerebrovascular disease, heart failure, chronic kidney disease, and peripheral vascular disease.¹⁴ It is not known how recent release from a correctional facility and a history of incarceration affect blood pressure (BP) control.

We used data from the Veterans Aging Cohort Study (VACS) to measure the association between incarceration and BP control following release in patients with hypertension and to evaluate putative mechanisms of observed associations. We hypothesized that in a population of patients with hypertension and a history of incarceration, recent or past, would be associated with uncontrolled BP.

METHODS

Sample

As previously described, VACS is a longitudinal, prospective, multi-site observational study of HIV-infected veterans and

matched uninfected veterans who receive healthcare services in the Veterans Health Administration (VHA).¹⁵ Briefly, VACS assesses a combination of self-reported, administrative, and clinical data from eight VHA clinical sites. Data collected include measures of patients' sociodemographic characteristics, comorbidities, and health behaviors. The institutional review boards at all locations approved the study, and all participants provided written informed consent prior to enrollment. We included VACS participants who completed the study follow-up survey between October 1, 2009, and September 30, 2010, who answered questions regarding incarceration history, and who met criteria for hypertension prior to the survey.

Participants met the criteria for hypertension if 1) on two instances during the period from 12 to 24 months prior to the survey, separated by at least 7 days, they had a systolic BP ≥ 140 mmHg or a diastolic BP ≥ 90 mmHg measured at any clinical encounter, or 2) they filled a prescription for an anti-hypertensive medication using VHA pharmacy refill data.¹⁶ As part of routine clinical visits, trained clinical staff measured BP using standard VHA protocols.

Exposure: History of Incarceration

We used two questions to assess history of incarceration. One question was "Have you ever spent any time in a jail, prison, detention center, or juvenile correctional facility?" to which participants could answer "yes," "no," or "don't know." A second question was "In the past year, how much time have you spent in a jail, prison, or detention center?" Using answers to these two questions, we categorized participants as having a recent history of incarceration (within the last year), a past history of incarceration (during lifetime but not during the last year), or no history of incarceration. Participants who did not answer these incarceration questions or answered "don't know" were not included in our analysis.

We described additional characteristics of incarceration history including number of times incarcerated and total time spent incarcerated. We also assessed participation in Veterans Justice Outreach (VJO) and Healthcare Re-entry for Veterans (HCRV), using clinic stop codes on outpatient encounters.¹² The HCRV program provides pre-release outreach and post-release case management services for incarcerated veterans released from state and federal prisons. The VJO initiative targets homelessness among veterans in contact with law enforcement, jails, and the courts by connecting them with treatment and social service resources.

Outcome: BP Control

We measured BP control using clinical data collected over the 12 months following the date the survey was administered. Uncontrolled BP was defined as a measured systolic BP ≥ 140 mmHg or a diastolic BP ≥ 90 mmHg on two separate occasions at least 7 days apart in the 12 months following the survey. We also performed sensitivity analyses using a poorly controlled BP, defined as systolic BP ≥ 160 mmHg or diastolic

BP ≥ 100 mmHg, as the outcome and the percentage of months that a person had BP controlled.¹⁷ Additionally, we measured the mean systolic BP and diastolic BP values during the 12 months following the survey.

Construction of Variables

We assessed age (continuous), HIV status (infected vs. uninfected), sex (male vs. female), race/ethnicity (black vs. non-black), education (<high school graduation vs. high school graduation and beyond), income (<\$12,000/year vs. $\geq$ \$12,000/year), body mass index (BMI, ≥ 25 vs. <25), unstable housing, unhealthy alcohol use, smoking (current vs. prior/never), and illicit drug use. We defined unstable housing as having spent at least one night in the year prior to survey in a homeless shelter, on the street, in a welfare hotel, in emergency/temporary housing or halfway house, doubled up with others, or in drug treatment. We classified persons as having unhealthy alcohol use if their total score on the Alcohol Use Disorders Identification Test–Consumption (AUDIT-C) was ≥ 4 and they reported drinking alcohol in the past year.^{18,19} We defined recent drug use as self-reported weekly use of cocaine, stimulants, or heroin, non-medical use of prescription opioids, or any intravenous drug use in the past year.

We evaluated post-traumatic stress disorder (PTSD), depression, primary care engagement, and antihypertensive medication adherence. We identified PTSD according to the diagnosis codes on at least one inpatient or two outpatient encounters.²⁰ We used a score of ≥ 10 on the Patient Health Questionnaire-9 to indicate active depressive symptoms.²¹

We measured primary care engagement using data from the VHA administrative database and defined it as ≥ 2 primary care visits at least 90 days apart in the period 12 to 24 months before the survey and, separately, the immediate 12 months following the survey.²² We measured receipt of antihypertensive medications in the 12 months following the survey using classification codes from the VHA pharmacy refill data, and then calculated the medication possession ratio as the percentage of days with antihypertensive medication.²³

Statistical Analysis

We described baseline characteristics by category of incarceration history (recent incarceration in the last year, past incarceration, or no history of incarceration). We also described the systolic and diastolic BP, control of BP, and receipt of antihypertensive medication. We used chi-square tests for categorical variables and ANOVA for continuous variables to compare between categories.

Next we performed logistic regression, examining the association between incarceration history and uncontrolled BP. We adjusted for covariates that we hypothesized a priori would confound the relationship between incarceration and BP control in a series of sequential multivariable models. Model 1 controlled for age, HIV status, sex, race/ethnicity, educational attainment, income, BMI, and housing status. For Model 2, we

Table 1 Baseline Characteristics of the Study Sample by Incarceration History (N = 2304)

	Recent incarceration		Past history of incarceration		Never incarcerated		Chi-square p-value
	No.	%	No.	%	No.	%	
Total	163	7	904	39	1237	54	
Age, years (mean, SD*)	55.7	6.2	57.1	7.3	58.9	9.2	<0.001
HIV infected at baseline	72	44	412	46	593	48	0.44
Male	157	96	888	98	1145	93	<0.001
Black race	133	82	680	75	756	61	<0.001
Education							
<High school	16	10	61	7	72	6	0.040
≥High school	141	87	827	91	1150	93	
Missing	6	4	16	2	15	1	
Low income							
No	107	66	474	52	465	38	<0.001
Yes	52	32	396	44	731	59	
Missing	4	2	34	4	41	3	
BMI†							
<25	29	18	228	25	280	23	0.045
≥25	99	61	491	54	740	60	
Missing	35	21	185	20	217	18	
Unstable housing	78	48	196	22	138	11	<0.001
Current smoker	94	58	430	48	322	26	<0.001
Unhealthy alcohol use							
Yes	48	29	180	20	163	13	<0.001
Low-risk/non-drinker	111	68	687	76	986	80	
Missing	4	2	37	4	88	7	
Illicit drug use in past year‡	36	22	165	18	124	10	<0.001
Engaged in primary care (pre-survey)	149	91	864	96	1165	94	0.070
HCRV§ or VJO¶ participation	17	10	18	2	NA		<0.001
PTSD¶	36	22	155	17	181	15	0.030
Depression	68	0.42	222	0.25	233	0.19	<0.001
Engaged in primary care (after survey)	144	88	802	89	1061	86	0.12
Antihypertensive adherent	69	42	463	51	655	53	0.040

*Standard deviation, p-value from ANOVA analysis

†Body mass index

‡Illicit drug use = weekly cocaine, stimulant, heroin, non-prescription opioid use, or any intravenous drug use in past year

§Health Care for Re-entry Veterans

¶Veterans Justice Outreach

¶Post-traumatic stress disorder

added behavioral factors: history of unhealthy alcohol use, smoking, illicit drug use, and primary care engagement prior to the survey.

We then performed mediation analyses to determine the influence of PTSD, depression, primary care engagement after the survey, and antihypertensive adherence on the relationship between incarceration history and BP control using Baron and Kenny mediation analysis.²⁴ This was a three-step process to determine whether (1) incarceration was associated with BP control, (2) incarceration was associated with the potential mediators, and (3) the association between incarceration and BP control was attenuated after adjustment for the potential mediators.

A p-value of <0.05 for was considered statistically significant. All statistical analyses were performed using SAS version 9.4 software (SAS Institute Inc., Cary, NC). We used variance inflation factor in the model with the most covariates to assess multicollinearity of covariates.

RESULTS

Among the 3515 VACS participants who completed the survey, 2304 participants met our inclusion criteria of having

hypertension and non-missing incarceration data. We excluded 136 participants who did not respond to questions on incarceration history, 258 participants who lacked BP measurements, and 817 who did not meet our criteria for hypertension. Of the 2304 in our study sample, 163 (7 %) reported recent incarceration and 904 (39 %) reported a past history of incarceration. Participants with recent or past history of incarceration were more likely to be younger and male, to have a low annual income, to not have completed high school, to have unhealthy alcohol use, and to report current smoking and illicit drug use compared with those who did not report a history of incarceration (Table 1).

Individuals recently incarcerated reported having more incarceration episodes with longer cumulative time incarcerated than those who reported a past history of incarceration. Participation in either VHA intervention program (HCRV or VJO) for veterans with criminal justice involvement was low among those with either recent (10 %) or past (2 %) incarceration.

Participants with recent incarceration or past history of incarceration were more likely to have uncontrolled BP than those without a history of incarceration (67 % vs. 56 % vs. 51 %, $p < 0.001$; Table 2). We did not observe a statistical difference in mean systolic BP according to incarceration

Table 2 Blood Pressure Control and Treatment by Incarceration History

	Recent incarceration		Past history of incarceration		Never incarcerated		p-value*
Blood pressure control	N	%	N	%	N	%	
Uncontrolled ($\geq 140/\geq 90$ mmHg)	110	67	510	56	628	51	<0.001
Poorly controlled ($\geq 160/\geq 100$ mmHg)	50	31	182	20	223	18	0.001
Blood pressure, mmHg	Mean	SD	Mean	SD	Mean	SD	
Systolic	132.1	12.1	131.1	12.2	130.4	12.6	0.19
Diastolic	80.5	8.4	79.7	8.6	78.0	9.2	<0.001

*Chi-square test for control and ANOVA for continuous blood pressure

history. We did note higher mean diastolic BP (80.5 mmHg) in those with recent incarceration compared to those with past history of incarceration (79.7 mmHg) or who were never incarcerated (78.0 mmHg, $p < 0.001$). We observed a difference in the distribution of BP values between the categories of incarceration history (Online Appendix Fig. 1). The upper quartile limits for systolic BP and diastolic BP were 141 mmHg and 87 mmHg, 139 mmHg and 85 mmHg, and 138 mmHg and 84 mmHg in those with recent incarceration, with past history of incarceration, and never incarcerated, respectively.

In the unadjusted analysis, recent incarceration (OR = 2.01, 95 % CI: 1.42–2.85) and past history of incarceration (OR = 1.26, 95 % CI: 1.06–1.49) were associated with uncontrolled BP in the year after the survey compared with participants without a history of incarceration (Table 3). In Model 1, the association between recent incarceration and uncontrolled BP persisted after controlling for age, HIV status, sex, race/ethnicity, educational attainment, income, BMI and housing status (adjusted odds ratio [AOR] = 1.64, 95 % CI: 1.14–2.36) when compared to those who were never incarcerated. However, the association between past history of incarceration and uncontrolled BP did not persist in this adjusted model (AOR = 1.12, 95 % CI: 0.94–1.34). The association between recent incarceration and uncontrolled BP compared with those who were never incarcerated also persisted in Model 2, which also controlled for history of smoking, unhealthy alcohol use, illicit drug use, and primary care engagement prior to the survey (AOR 1.57, 95 % CI: 1.09–2.26).

We explored PTSD, depression, primary care engagement after the survey, and antihypertensive adherence as putative mediators. Primary care engagement after the survey did not meet the requirement of being associated with both the exposure (incarceration history) and outcome (uncontrolled hypertension). In the mediation analysis, we ran separate models adding PTSD, depression, or antihypertensive adherence separately to those variables in Model 2. The adjusted odds ratio of recent incarceration compared to never incarceration was not significantly impacted when we added PTSD (recent vs. never incarcerated AOR 1.55, 95 % CI: 1.07–2.23) or depression (recent vs. never incarcerated AOR 1.49, 95 % CI: 1.03–2.16) or antihypertensive adherence (recent vs. never incarcerated AOR 1.58, 95 % CI: 1.09–2.27).

In the sensitivity analysis using a higher cutoff for BP control (SBP ≥ 160 or DBP ≥ 100), we found that participants with recent incarceration or past history of incarceration were more likely to have poorly controlled BP than those without a history of incarceration (31 % vs. 20 % vs. 18 %, $p = 0.001$; Table 2). The association between recent incarceration and poorly controlled BP in the fully adjusted model was consistent in effect magnitude and direction (Online Appendix Table 1). We also found that participants with recent incarceration had a lower percentage of months of controlled BP than those without a history of incarceration (72 % vs. 76 % vs. 78 %, recent vs. never $p = 0.005$, past vs. never $p = 0.09$).

DISCUSSION

In a large multi-site cohort study, we found that among participants with hypertension, a recent history of incarceration was associated with increased odds of having uncontrolled BP. Previous studies have suggested that known mechanisms such as HIV status, educational status, low income, BMI, housing status, unhealthy alcohol use, and illicit drug use, all of which are more frequent in people with a history of incarceration, can explain disparities in hypertension outcomes in patients with a history of incarceration, but our study suggests that other mechanisms may play a role.^{8, 13}

Recent incarceration could have an adverse effect on BP control, particularly impacting control of diastolic BP. The period immediately after release from prison or jail can lead to discontinuity in medical care and instability in many facets of life; people have many competing concerns, including finding housing and employment and reunifying with family, in addition to managing chronic medical issues and engaging in healthcare.^{25, 26} While we did not find that housing status or income level impacted the association between recent incarceration and hypertension, increased levels of stress during incarceration or in the post-incarceration period may complicate BP control following release from a correctional facility.^{27–29} We also found that individuals with recent incarceration were incarcerated more times and for a longer cumulative time than those who had a past history of incarceration. Therefore, recent incarceration may be a marker for a different pattern of exposure to the criminal justice system, which has an effect on BP control.

Table 3 Association Between Incarceration History and Uncontrolled Blood Pressure

	Bivariate Models	Multivariable Model 1	Multivariable Model 2
	OR (95 % CI)	OR (95 % CI)	OR (95 % CI)
Incarceration history			
Never incarcerated	Reference	Reference	Reference
Past history of incarceration	1.26 (1.06–1.49)	1.12 (0.94–1.34)	1.08 (0.90–1.30)
Recent incarceration	2.01 (1.42–2.85)	1.64 (1.14–2.36)	1.57 (1.09–2.26)
Age, years	1.00 (0.99–1.01)	1.01 (1.00–1.02)	1.01 (1.00–1.02)
HIV status at baseline			
Non-infected	Reference	Reference	Reference
Infected	0.87 (0.74–1.03)	0.86 (0.72–1.02)	0.86 (0.72–1.03)
Sex			
Female	Reference	Reference	Reference
Male	1.28 (0.88–1.87)	1.28 (0.86–1.89)	1.30 (0.88–1.93)
Race			
Non-black	Reference	Reference	Reference
Black	1.72 (1.44–2.05)	1.63 (1.36–1.96)	1.64 (1.37–1.98)
Education			
<High school	Reference	Reference	Reference
≥High school	0.85 (0.61–1.19)	0.97 (0.69–1.38)	0.96 (0.68–1.36)
Missing	1.20 (0.57–2.52)	1.20 (0.56–2.60)	1.23 (0.57–2.65)
Low income			
No	Reference	Reference	Reference
Yes	1.41 (1.20–1.67)	1.29 (1.09–1.54)	1.28 (1.07–1.53)
Missing	1.19 (0.75–1.88)	1.08 (0.67–1.73)	1.08 (0.67–1.74)
BMI*			
<25	Reference	Reference	Reference
≥25	1.10 (0.90–1.34)	1.11 (0.90–1.38)	1.14 (0.92–1.41)
Unknown	1.07 (0.83–1.38)	1.05 (0.81–1.37)	1.06 (0.81–1.37)
Unstable housing			
No/Unknown	Reference	Reference	Reference
Yes	1.38 (1.11–1.72)	1.15 (0.92–1.45)	1.10 (0.87–1.39)
History of smoking			
Other	Reference		Reference
Current	1.24 (1.05–1.47)		1.08 (0.90–1.30)
Unhealthy alcohol use			
Low-risk/non-drinker	Reference		Reference
Yes	1.10 (0.88–1.37)		1.02 (0.81–1.28)
Missing	1.02 (0.71–1.46)		1.06 (0.73–1.52)
Illicit drug use in past year			
No	Reference		Reference
Yes	1.49 (1.17–1.89)		1.43 (1.11–1.83)
Primary care engagement (pre-survey)			
No	Reference		Reference
Yes	0.88 (0.61–1.27)		0.90 (0.62–1.31)
PTSD†			
No	Reference		
Yes	1.27 (1.02–1.59)		
Depression			
No/Missing	Reference		
Yes	1.46 (1.20–1.79)		
Primary care engagement (after survey)			
No	Reference		
Yes	2.87 (2.22–3.72)		
Antihypertensive adherent			
No	Reference		
Yes	1.22 (1.03–1.43)		

*Body mass index

†Post-traumatic stress disorder

Furthermore, although healthcare is constitutionally mandated while people are incarcerated and patients have access to antihypertensive medications, most incarcerated patients are not permitted to manage their own medications while incarcerated and have low rates of health literacy. Thus, patients can be released back to the community without skills in self-management and are unable to adhere to their medications on release.³⁰ Adherence could play a larger role in BP control outside the VHA, where individuals may not have access to healthcare. Another possible factor is that provider behaviors

differ when engaging with patients with a history of incarceration, either because of the stigma associated with incarceration or concerns around discontinuity of care.

Other explanations for worse control of hypertension that warrant exploration include care coordination, which could improve management of chronic conditions.^{31–33} In our study, we found that few individuals just released from correctional facilities were connected with the VHA reentry programs.³⁴ Implementation of these reentry programs is varied, suggesting a possible intervention model that includes more

widespread engagement prior to release, to improve BP control in patients with recent incarceration.^{12, 35, 36} Further study of these programs is needed, as increased participation may ameliorate some of the adverse cardiovascular health effects associated with release from prison or jail.

Given our findings, providers may consider screening for a recent history of incarceration, as it may alert them to patients who need extra attention to improve BP control. Moreover, as several other studies have shown that recent incarceration is associated with worse control of other chronic conditions, the benefits of screening are not limited to BP control.^{37–39} That said, if the health effect of having a history of incarceration is mediated by stigma and provider behaviors, screening for incarceration history may have a detrimental effect.³⁰

There are several limitations to our study. Given that this is an observational study, we cannot attribute causality to the associations we observed. History of incarceration, unhealthy alcohol use, smoking, and illicit drug use were self-reported, so social desirability bias may be present. In addition, although we controlled for the effect of unhealthy alcohol use and illicit drug use on BP control, we were not able to control for severe substance use disorders, which may have a greater effect on BP control. We measured BP control differently from another national study in the VHA population, but in sensitivity analysis using their measure found similar levels of BP control.¹⁷ Also, although we found a significant association between worse BP control and recent incarceration, the difference in mean systolic BP was not significant, and the difference in diastolic BP was relatively small. Studies have shown that in younger patients, elevated diastolic BP is a better predictor of future coronary heart disease than systolic BP.⁴⁰ The analysis of continuous measurements of systolic and diastolic BP does not convey the clinical importance of certain threshold values.

There is also danger of misclassification of receipt of anti-hypertensive medications, as these medications can be prescribed for other indications, such as heart failure and proteinuria, but this should not vary by incarceration history. We did not account for medications received outside the VHA system, though this effect would likely be small, as most VHA patients get their medications from the VHA system.^{15, 41} In addition, our measurement of primary care engagement was limited and may not completely describe the interaction between primary care engagement and BP control.

For our exposure of interest, history of incarceration, we could not distinguish between exposure to jail versus prison. This is a potential limitation, as these two correctional environments may have different effects on control of BP. Our findings may not be generalizable to individuals receiving care outside the VHA system, where individuals with and without a history of incarceration may have differential levels of access to medical care, medications, and care coordination prior to release.¹² Finally, generalizability of our findings may be limited, as VACS is a cohort of HIV-infected and matched controls and does not represent the VHA patient population. Notwithstanding these limitations, these data come from

clinical, pharmacologic, and administrative databases, and provide robust information on the health outcomes and potential confounders of individuals released from correctional facilities.

CONCLUSIONS

In patients with hypertension, a history of recent incarceration is associated with higher odds of having uncontrolled BP compared with participants who have not been recently incarcerated. We suggest that more longitudinal studies need to be conducted, looking at the relationship between incarceration and BP control. Our study also suggests that specific interventions need to be developed for patients with a recent history of incarceration, to improve BP control and to reduce disparities in cardiovascular outcomes.

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Corresponding Author: Benjamin A. Howell, MD MPH; Department of Internal Medicine, Yale University School of Medicine, P.O. Box 208030, New Haven, CT 06520, USA (e-mail: benjamin.howell@yale.edu).

Compliance with Ethical Standards:

Conflict of Interest: Dr. Fiellin has received honoraria from Pinney Associates for serving on an external advisory board monitoring the diversion and abuse of buprenorphine products. The other authors declare that they do not have a conflict of interest.

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