Supplementary Appendix

This appendix has been provided by the authors to give readers additional information about their work.

Supplement to: Chin ET, Leidner D, Ryckman T, et al. Covid-19 vaccine acceptance in California state prisons. N Engl J Med. DOI: 10.1056/NEJMc2105282

SUPPLEMENTARY APPENDIX

Supplement to: Chin ET, Leidner D, Ryckman T, et al. Covid-19 vaccine acceptance in California state prisons. N Engl J Med 2021.

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I. Vaccination Program

The California Department of Corrections and Rehabilitation (CDCR) launched a vaccination program for residents of its 35 prison facilities on December 22, 2020. The program began in three prisons with the largest medically vulnerable populations. Rollouts at other prisons followed, with the last prison commencing vaccinations on January 19, 2021.

Within prisons, the criteria CDCR used to prioritize residents for vaccination changed over time as vaccine shipments arrived and new state and federal guidances were issued. The prioritization criteria variously included residency in specialized medical or psychiatric care settings, risk factors for severe outcomes from Covid-19, no confirmed SARS-CoV-2 infection (or none in the previous 90 days), employment in a high-contact job, and due dates for a second dose.

Vaccine offers were made verbally and in person. Residents who accepted were vaccinated on the spot. Offers, acceptances, and declinations were recorded in CDCR's electronic health record.

Residents received one of the two vaccines (Pfizer-BioNTech or Moderna) authorized for emergency use in the U.S. at the time of our study period, December 22, 2020, through March 4, 2021. Vaccination was voluntary, and residents were permitted to decline without sanction. Prison healthcare staff recorded whether each vaccine dose offered was accepted or declined. Residents who declined a vaccine dose were eligible to be re-offered one at a later time.

II. Data and Variables

Derivation of analytic sample: The daily extracts provided by the California Department of Corrections and Rehabilitation included a unique pseudo-identifier that allowed us to follow individual residents over time. The analytic sample comprised all individuals who spent at least one night incarcerated in a CDCR prison during the study period (Table S2). A total of 246

offerees (0.4%) were excluded from the multivariable analyses because of missing values for the room type or security-level variables.

Variables: In addition to information on residents' demographic characteristics, the data included various carceral characteristics with potential relevance for vaccine acceptance—particularly, security level, room type, and participation in penal labor. Additional details follow.

> *Racial or ethnic group*. We grouped race and ethnicity information, which came from a combination of self-reports and administrative records, into categories used by the U.S. Census Bureau (Hispanic, non-Hispanic Black, non-Hispanic White, non-Hispanic American Indian/Alaska Native, non-Hispanic Asian/Pacific Islander, and non-Hispanic Other).[1]
>
> *Covid-19 risk score*. This risk score was developed by CDCR to grade a resident's risk of severe outcomes following SARS-CoV-2 infection, and sums weighted values for items identified in the scientific literature as risk factors (Table S1 describes the 17 items). We classified risk scores of 0-1 as "low", scores of 2-3 "medium", and scores of 4 or greater "high". Low-scoring residents were aged younger than 65 years and had no more than 1 comorbidity; medium-scoring residents were aged younger than 65 years with 2 or 3 comorbidities; and high-scoring residents were aged 65 years and/or older or had 4 or more comorbidities.
>
> *History of Covid-19*. The data also included Covid-19 testing information. CDCR has undertaken extensive testing of residents for SARS-CoV-2 since April 2020, using real-time PCR and antigen tests.[2] We defined a history of Covid-19 as having had at least one positive test while in CDCR custody.
>
> *Security level*. CDCR rates each resident's security level from 1 (lowest) to 4 (highest), based on a multifactorial assessment of the resident's risk of misconduct; this rating influences housing placement and eligibility for activities such as visitations, recreation, and penal labor.
>
> *Room type*. Residents are housed in rooms, discrete spaces that are at least partially enclosed by solid walls. We defined room type according to the number of residents housed in each room, dichotomizing this variable into cells (rooms with 1-2 occupants) and dormitories ($\geq$3 occupants).
>
> *Penal labor*. Using information on residents' participation in work roles (e.g., janitorial, food preparation), we created a binary variable indicating whether each resident had participated in penal labor within the prior 14 days.

Assignment of values to time-varying variables: Except for the race or ethnicity and sex variables, the variables in the CDCR person-day data were time-varying in nature, meaning that their values changed for some residents during the study period. For purposes of our multivariable analysis, we fixed the values for Covid-19 risk score, age group, history of Covid-

19, room type, participation in penal labor, and prison according to the values specified on the day of their first offer.

III. Statistical Analysis

We calculated the proportion of residents who accepted at least one vaccine dose among residents offered those doses ("offerees"). We also calculated patterns of acceptance among residents who were re-offered vaccines after declining a first-dose.

We used multivariable logistic regression analysis to identify demographic characteristics associated with vaccine acceptance at the resident level. The outcome variable distinguished offerees who accepted ≥1 vaccine doses from offerees who did not accept any doses. The four predictors of interest were age group (18-39 years, 40-64 years, ≥65 years), racial or ethnic group (Hispanic, non-Hispanic Black, non-Hispanic White, non-Hispanic American Indian/Alaska Native, non-Hispanic Asian/Pacific Islander, non-Hispanic Other), Covid-19 risk score (low, medium, high), and history of Covid-19 (yes, no).

In addition, we included two interaction terms: (1) Covid-19 risk score and racial or ethnic group, and (2) age group and racial or ethnic group. Our main rationale for including these interactions was prior indications that younger members of minorities have especially high levels of hesitancy.[3]

Two of our predictors of interest—Covid-19 risk score and age variables are highly collinear—partly a function of the fact age is a heavily weighted item in the risk score. This precluded inclusion of both variables in the same model. However, we sought to avoid choosing one of these variables and excluding the other because improving understanding of the extent to which vaccine uptake varies according to both variables has policy relevance. CDCR has been using the Covid-19 risk score in operational decisions regarding protection of vulnerable inmates (e.g., those with high scores are prioritized for release or relocation from dormitories to cells); the score also includes information that age alone does not about comorbidities identified in the scientific literature as risk factors for severe Covid-19-related illness. Age, on the other hand, is an independent risk factor for severe disease, and a readily interpretable one for prison systems outside California that do not use CDCR's Covid-19 risk score.

Thus, to preserve our ability to present adjusted estimates for both variables, we fit two models. The first model included the Covid-19 risk score and the interactions between Covid-19 risk score and racial or ethnic group; it excluded both age and the interactions between age and racial or ethnic group. All reported estimates, except those for the age group variable and the interaction between age group and racial or ethnic group, come from this model. The second model included age groups and the interactions between age groups and racial or ethnic group; it excluded both Covid-19 risk score and the interactions between Covid-19 risk score and racial or ethnic group. The only reported estimates that come from this second model are the age group estimates and the interactions between age group and racial or ethnic group.

Both models adjusted for residents' security level (1, 2, 3, 4), room type (cell, dorm), and participation in penal labor (yes, no). In addition, to help ensure unbiased estimates, we specified prison-level fixed effects, a modeling choice influenced by two considerations. First, unlike a random effects specification, fixed effects are more conservative in that they do not depend on an assumption of non-correlation with independent variables—an assumption that is likely violated in our analysis. Second, our study sample represented the majority of the CDCR population and all CDCR prisons commenced vaccination during the study period.

The Research Letter reports predicted margins estimated from the multivariable analyses. Complete estimates from the models that produced these predicted margins are provided in Table S3, below.

Analyses were performed using R software, version 3.5.2 (R Foundation for Statistical Computing). We performed post hoc Bonferroni correction to account for multiple comparisons (n=14) by estimating 99.6% confidence intervals for the reported predicted margins instead of 95% confidence intervals.

IV. Ethics Approval

The study was approved by the institutional review board at Stanford University (protocol #55835).

V. Exhibits

Table S1. Covid-19 risk score

Condition	Definition	Weighted Score
Age 65+	Chronologic age of 65 years or above	4
Advanced liver disease	Advanced liver disease (cirrhosis/end stage liver disease)	2
Asthma	Persistent asthma (moderate or severe) as defined by the California Correctional Health Care Services (CCHCS) asthma condition specifications	1
Cancer	High risk cancer as defined by the CCHCS cancer condition specifications (excludes most diagnoses of skin cancer and "personal history of" cancers")	2
Chronic Kidney Disease	Chronic kidney disease as defined by the CCHCS chronic kidney disease condition specifications	1
Advanced Chronic Kidney Disease/Renal Failure	Chronic kidney disease (Stage 5) as defined by the CCHCS Chronic Kidney Disease Condition Specifications OR currently receiving Hemodialysis	1
Chronic Lung Disease (other)	Cystic fibrosis, pneumoconiosis, or pulmonary fibrosis	1
COPD	Chronic obstructive pulmonary disease	2
Diabetes	Diabetes	1
Diabetes (high risk)	High risk diabetes as defined by the CCHS diabetes condition specifications	1
Heart Disease	Any of the following cardiovascular disease conditions: Cerebrovascular, Congestive Heart Failure, Congenital Heart Disease, Ischemic Heart Disease, Peripheral Vascular Disease, Thromboembolic Disease, Valvular Disease, and Cardiovascular Disease-Not Otherwise Specified.	1
Heart Disease (high risk)	High risk heart disease as defined by CCHCS condition specifications	1
Hemoglobin Disorder	Hemoglobin disorders as defined by CCHCS Condition Specifications for Hemoglobinopathy, including Sickle Cell Disorder.	1
HIV	HIV	1
HIV (poorly controlled)	HIV with a CD4 count < 200	1
Hypertension	Hypertension as defined by the CCHCS Hypertension Condition Specifications	1
Immunocompromised	Any of the following conditions: aplastic anemia, histiocytosis, immunosuppressed, organ transplant, other transplant	2
Neurologic conditions	Dementia, Parkinson's Disease, Multiple Sclerosis, Myasthenia Gravis, or Neurologic Disorder as defined by CCHCS condition specifications	1
Obesity	Body mass index of 30 or above	1
Other high risk chronic condition	Any of the following conditions when they are high risk per CCHCS condition specifications: Coccidioidomycosis, Connective Tissue Disorder, Endocrine Disorder, or Vasculitis	1
Pregnant	Actively pregnant	1

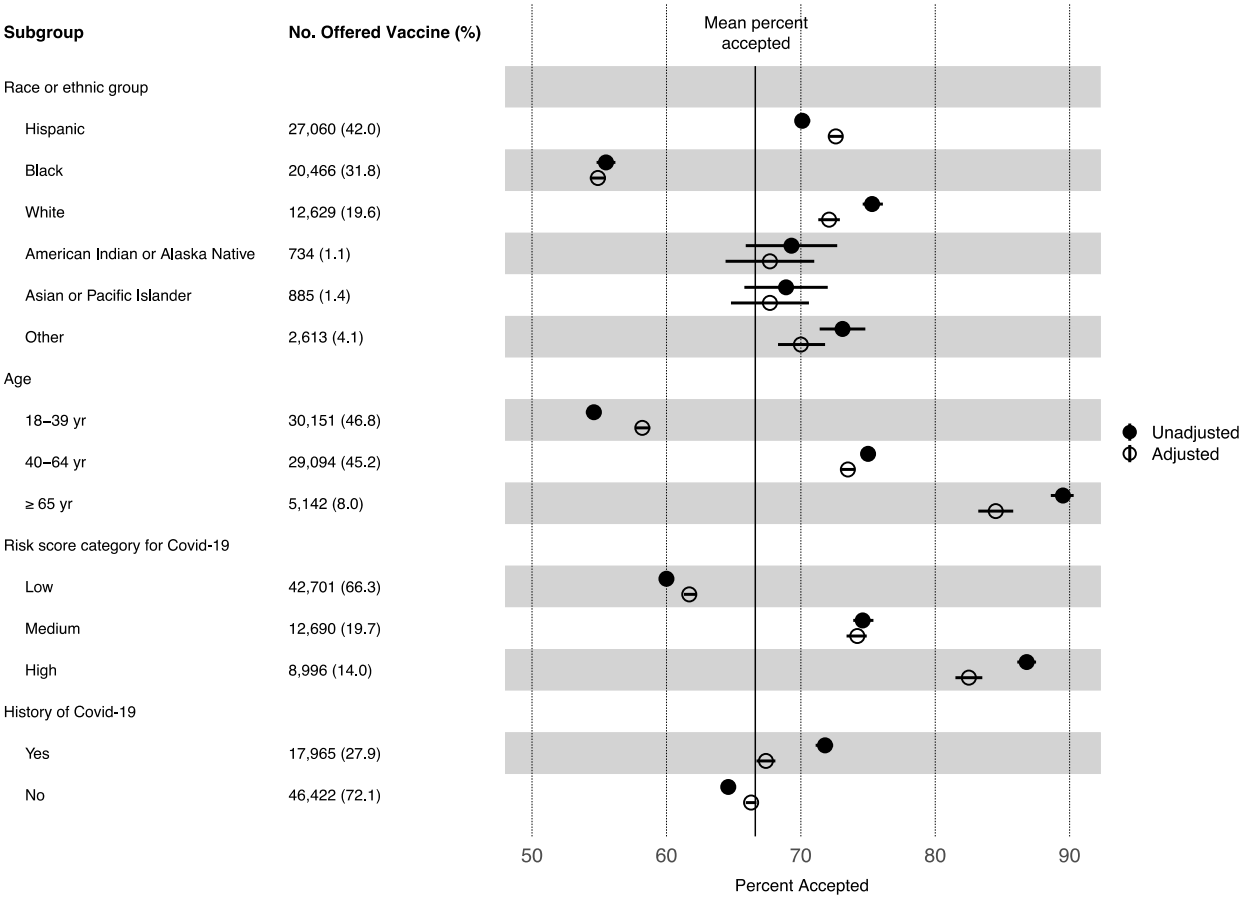
Table S2. Demographic, health characteristics, and history of Covid-19 of incarcerated residents according to vaccination status.

	Total (N=97,779)	Offered (N=64,633)	Accepted (N=42,952)	Re-offered (N=1,962)
Demographic Characteristics				
Age years - Median (IQR)	40 (32-52)	41 (32-53)	44 (34-56)	40 (31-53)
Age category - no. (%)				
18-39	46,163 (47.2%)	30,307 (46.9%)	16,487 (38.4%)	937 (47.8%)
40-64	45,334 (46.4%)	29,176 (45.1%)	21,859 (50.9%)	820 (41.8%)
65+	6,282 (6.4%)	5,150 (8%)	4,606 (10.7%)	205 (10.4%)
Race or ethnicity - no. (%)				
Hispanic	43,624 (44.6%)	27,165 (42%)	19,018 (44.3%)	714 (36.4%)
Black, non-Hispanic	28,370 (29%)	20,506 (31.7%)	11,375 (26.5%)	760 (38.7%)
White, non-Hispanic	19,276 (19.7%)	12,716 (19.7%)	9,527 (22.2%)	374 (19.1%)
American Indian/Alaska Native, non-Hispanic	1,147 (1.2%)	739 (1.1%)	509 (1.2%)	13 (0.7%)
Asian/Pacific Islander, non-Hispanic	1,372 (1.4%)	892 (1.4%)	612 (1.5%)	32 (1.6%)
Other, non-Hispanic	3,986 (4.1%)	2,615 (4%)	1,911 (4.4%)	69 (3.5%)
Sex - no. (%)				
Male	94,410 (96.6%)	61,820 (95.6%)	41,145 (95.8%)	1,886 (96.1%)
Female	3,369 (3.4%)	2,813 (4.4%)	1,807 (4.2%)	76 (3.9%)
Clinical Characteristics				
Covid-19 risk score - Median (IQR)	1 (0-2)	1 (0-2)	1 (0-3)	1 (0-3)
Covid-19 risk score category - no. (%)				
Low	68,504 (70.1%)	42,906 (66.4%)	25,655 (59.7%)	1,170 (59.6%)
Medium	18,318 (18.7%)	12,723 (19.7%)	9,482 (22.1%)	417 (21.3%)
High	10,957 (11.2%)	9,004 (13.9%)	7,815 (18.2%)	375 (19.1%)
BMI - Median (IQR)	28 (26-32)	28 (26-32)	29 (26-32)	28 (25-32)
Medical conditions - no. (%)				
Any pre-existing condition*	51,430 (52.6%)	35,328 (54.7%)	25,664 (59.8%)	1,115 (56.8%)
Advanced Liver Disease	3,256 (3.3%)	2,572 (4%)	2,277 (5.3%)	85 (4.3%)
Asthma	12,745 (13%)	8,998 (13.9%)	5,916 (13.8%)	297 (15.1%)
Dialysis	73 (0.1%)	69 (0.1%)	64 (0.1%)	<10
Immunocompromised	1,225 (1.3%)	993 (1.5%)	794 (1.8%)	43 (2.2%)
Lung Disease	127 (0.1%)	97 (0.2%)	91 (0.2%)	<10
Pregnancy	<10 (0%)	<10 (0%)	<10 (0%)	0
Overweight (25 < BMI < 30)	34,563 (35.3%)	22,093 (34.2%)	14,509 (33.8%)	637 (32.5%)
Obese (30 ≤ BMI < 40)	35,082 (35.9%)	23,555 (36.4%)	16,487 (38.4%)	707 (36%)
Severe Obesity (BMI ≥ 40)	3,909 (4%)	2,750 (4.3%)	1,973 (4.6%)	101 (5.1%)
Chronic Kidney Disease	14,005 (14.3%)	10,401 (16.1%)	8,448 (19.7%)	346 (17.6%)
Chronic obstructive pulmonary disease	2,741 (2.8%)	2,224 (3.4%)	1,957 (4.6%)	71 (3.6%)
Connective Tissue Disease	701 (0.7%)	553 (0.9%)	436 (1%)	20 (1%)
Cardiovascular Disease	4,398 (4.5%)	3,453 (5.3%)	2,786 (6.5%)	143 (7.3%)
Cancer	2,706 (2.8%)	2,105 (3.3%)	1,785 (4.2%)	75 (3.8%)

Coccidioidomycosis	881 (0.9%)	583 (0.9%)	409 (1%)	16 (0.8%)
Dementia or Parkinson's	503 (0.5%)	436 (0.7%)	364 (0.8%)	34 (1.7%)
Diabetes	7,834 (8%)	5,938 (9.2%)	5,049 (11.8%)	235 (12%)
Endocrine Disorder	110 (0.1%)	94 (0.1%)	85 (0.2%)	<10
HIV	734 (0.8%)	556 (0.9%)	454 (1.1%)	21 (1.1%)
Hypertension	24,447 (25%)	17,656 (27.3%)	13,765 (32%)	647 (33%)
Hemoglobinopathy	888 (0.9%)	674 (1%)	447 (1%)	33 (1.7%)
Multiple Sclerosis	60 (0.1%)	49 (0.1%)	36 (0.1%)	<10
Myasthenia Gravis	25 (0%)	22 (0%)	12 (0%)	<10
Neurologic Disorder	143 (0.1%)	123 (0.2%)	102 (0.2%)	<10
Vasculitis	41 (0%)	32 (0%)	24 (0.1%)	0
History of Covid-19 – no. (%)	46,162 (47.2%)	17,968 (27.8%)	12,898 (30%)	223 (11.4%)
Disability - no. (%)				
Any disability†	37,517 (38.4%)	27,049 (41.9%)	19,236 (44.8%)	972 (49.5%)
Cognitive	1,279 (1.3%)	1,105 (1.7%)	881 (2.1%)	56 (2.9%)
Hearing	3,296 (3.4%)	2,372 (3.7%)	2,003 (4.7%)	88 (4.5%)
Mental Health	31,227 (31.9%)	22,505 (34.8%)	15,533 (36.2%)	820 (41.8%)
Mobility	10,389 (10.6%)	8,005 (12.4%)	6,559 (15.3%)	311 (15.9%)
Speech	72 (0.1%)	56 (0.1%)	45 (0.1%)	<10
Vision	692 (0.7%)	554 (0.9%)	440 (1%)	29 (1.5%)
Reading level - Median (IQR)	8.7 (5.2-11.8)	8.6 (5.2-11.3)	9 (5.1-11.8)	8 (5-10.8)
Carceral Characteristics				
Room type - no. (%)				
Cell	67,946 (69.5%)	47,931 (74.2%)	30,895 (71.9%)	1,384 (70.5%)
Dorm	29,833 (30.5%)	16,702 (25.8%)	12,057 (28.1%)	578 (29.5%)
Security level - no. (%)				
1 (minimum)	8,474 (8.7%)	5,466 (8.5%)	3,282 (7.6%)	251 (12.8%)
2	46,191 (47.2%)	27,637 (42.8%)	21,134 (49.2%)	880 (44.9%)
3	15,847 (16.2%)	10,534 (16.3%)	6,391 (14.9%)	278 (14.2%)
4 (maximum)	26,454 (27.1%)	20,750 (32.1%)	12,081 (28.1%)	541 (27.6%)
Participation in penal labor - no. (%)	30,285 (31%)	18,582 (28.8%)	12,753 (29.7%)	424 (21.6%)

* Refers to the set of conditions identified by the Centers for Disease Control and Prevention as risk factors for increased risk of severe Covid-19 illness among adults of any age, specifically: cancer, chronic kidney disease, on dialysis, chronic obstructive pulmonary disease, cardiovascular disease, obesity, severe obesity, pregnancy, hemoglobinopathy disorders, diabetes.
† Refers to presence of disabilities in six categories: cognitive, hearing, mental health, mobility, speech, and vision.

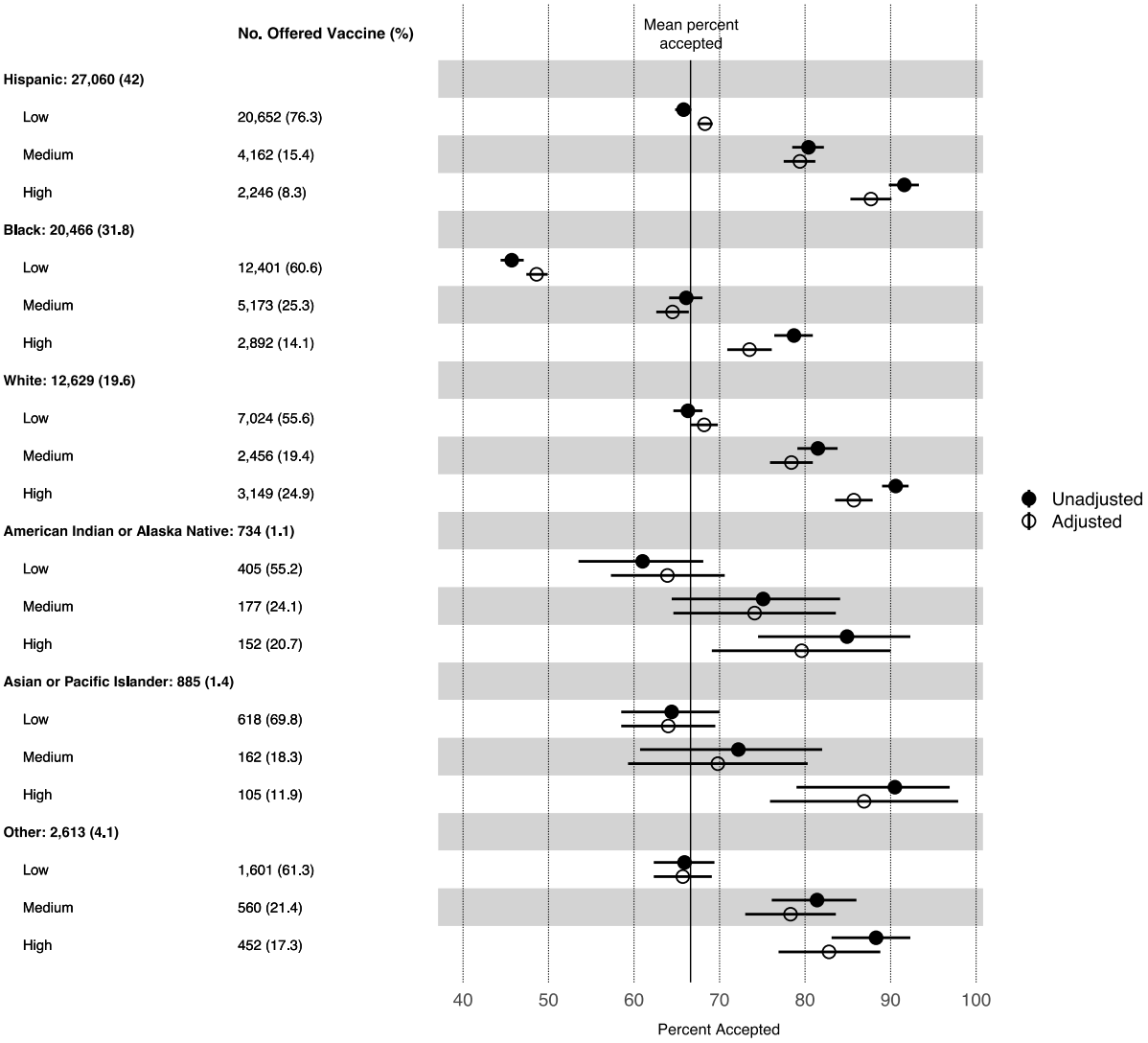
Figure S1. Unadjusted and adjusted proportions of residents of California state prisons offered a Covid-19 vaccination who accepted at least one dose.*



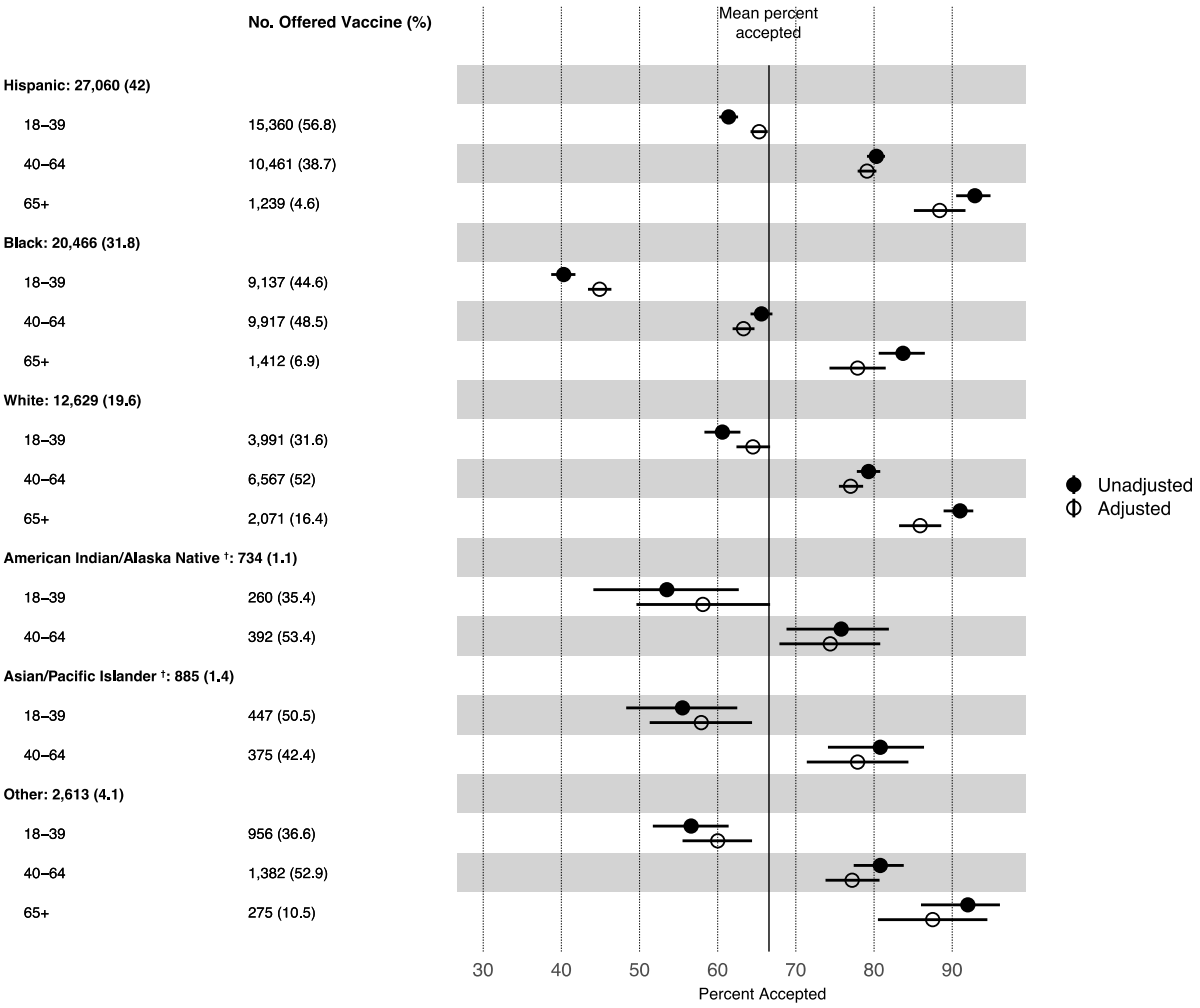
Shown are the predicted margins estimated from the results of multivariable logistic-regression analyses of the sample of 64,387 prison residents who were offered at least one dose, with adjustments for room type (defined according to the number of residents housed in a room), participation in penal labor, security level, and prison. Details of the model specification and a complete set of results are provided in Table S3. All the categories of race or ethnic group other than Hispanic indicate non-Hispanic residents. The California Department of Corrections and Rehabilitation (CDCR) developed a risk score for Covid-19 to grade residents' likelihood of severe Covid-19–related disease. The risk score sums weighted values for 17 items identified in the scientific literature as risk factors for severe outcomes after SARS-CoV-2 infection (Table S1). We categorized scores into low risk (score of 0 or 1), medium risk (2 or 3), and high risk (≥4). Residents were considered to have had a history of Covid-19 if they had had a positive test result while in CDCR custody, before the date of the first offer of a vaccine.

Figure S2. Vaccination acceptances among incarcerated residents by (A) Racial or ethnic group and Covid-19 risk score (B) Racial or ethnic group and age group.*

A



B



* The plots show predicted margins estimated from results of two multivariable logistic regression analyses. The estimates shown in Panel A come from the model reported in Table S3 that included Covid-19 risk score (column 1). The estimates shown in Panel B come from the model reported in Table S3 that included age (column 2). A complete set of estimates from these models is reported in Table S3.
† Adjusted estimates for groups consisting of fewer than 100 residents are not reported.

Table S3. Adjusted odds ratios for the analysis.*

			Acceptance among offerees	
			Specification with Covid-19 risk score	**Specification with Age**
			Odds Ratio (95% CI)	*Odds Ratio (95% CI)*
Race or ethnic group	White (Ref)		1.00	1.00
	Hispanic		1.01 (0.95 – 1.07)	1.04 (0.96 – 1.12)
	Black		0.4 (0.38 – 0.43)	0.41 (0.38 – 0.45)
	American Indian/Alaska Native		0.81 (0.65 – 1.01)	0.74 (0.57 – 0.97)
	Asian/Pacific Islander		0.81 (0.68 – 0.98)	0.73 (0.60 – 0.90)
	Other		0.88 (0.78 – 1.00)	0.81 (0.69 – 0.94)
Covid-19 risk score	Low (Ref)		1.00	
	Medium		1.77 (1.58 – 2.00)	
	High		3.03 (2.64 – 3.46)	
Covid-19 risk score : Race or ethnic group	Medium	Hispanic	1.06 (0.91 – 1.22)	
		Black	1.16 (1.01 – 1.33)	
		American Indian/Alaska Native	0.95 (0.62 – 1.46)	
		Asian/Pacific Islander	0.75 (0.50 – 1.14)	
		Other	1.13 (0.86 – 1.48)	
	High	Hispanic	1.2 (0.98 – 1.47)	
		Black	1.09 (0.92 – 1.28)	
		American Indian/Alaska Native	0.78 (0.47 – 1.31)	
		Asian/Pacific Islander	1.37 (0.68 – 2.77)	
		Other	0.9 (0.64 – 1.27)	
Age	18-39 (Ref)			1.00
	40-64			1.95 (1.78 – 2.13)
	65+			3.67

				(3.10 – 4.35)
Age : Race or ethnic group	40-64	Hispanic		1.09
				(0.98 – 1.22)
		Black		1.18
				(1.05 – 1.31)
		American Indian/Alaska Native		1.15
				(0.80 – 1.65)
		Asian/Pacific Islander		1.43
				(1.01 – 2.02)
		Other		1.25
				(1.01 – 1.55)
	65+	Hispanic		1.22
				(0.92 – 1.61)
		Black		1.36
				(1.08 – 1.70)
		American Indian/Alaska Native		1.18
				(0.55 – 2.54)
		Asian/Pacific Islander		1.82
				(0.63 – 5.24)
		Other		1.44
				(0.88 – 2.35)
History of Covid-19		Yes (Ref)	1.00	1.00
		No	0.95	0.93
			(0.91 – 0.99)	(0.89 – 0.97)
Room type		Cell (Ref)	1.00	1.00
		Dorm	0.97	0.97
			(0.91 – 1.04)	(0.91 – 1.04)
Penal labor		No (Ref)	1.00	1.00
		Yes	1.16	1.1
			(1.11 – 1.21)	(1.06 – 1.15)
Security level		I	1.00	1.00
		II	1.41	1.42
			(1.32 – 1.52)	(1.32 – 1.52)
		III	0.97	1.08
			(0.89 – 1.06)	(0.99 – 1.17)
		IV	0.82	0.89
			(0.75 – 0.89)	(0.82 – 0.97)
		Observations	64387	

* Prison-level fixed effects were included in all models but are not reported in the table.

References

1. U.S. Census Bureau. 2010 census summary file 1— technical documentation. Washington, DC: U.S. Department of Commerce. SF1/10-4 (RV).
2. Chin ET, Ryckman T, Prince L, et al. Covid-19 in the California state prison system: an observational study of decarceration, ongoing risks, and risk factors. medRxiv 2021;2021.03.04.21252942.
3. Chin ET, Goldhaber-Fiebert JD, Ryckman T, et al. Covid-19 Testing Hesitancy Among Incarcerated Men in California. Under review.