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## Examining the Relationship Between Adverse Childhood Experiences and COVID-19 Vaccine Status using 2022 BRFSS Data: A Cross-Sectional Study

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1 Title  
2 Examining the Relationship Between Adverse Childhood Experiences and COVID-19  
3 Vaccine Status using 2022 BRFSS Data: A Cross-Sectional Study

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9

10 Abstract:

11

12 Objective. To determine the association between adverse childhood experiences  
13 (ACEs) scores with COVID-19 vaccination outcomes before and after adjusting for  
14 demographic variables.

15

16 Methods. Data were from 2022 Behavioral Risk Factor Surveillance System (BRFSS)  
17 surveys regarding 13 categories of ACEs, COVID-19 vaccination, and demographic  
18 variables. Data was weight adjusted for survey respondent data. This complex design  
19 combined the core and optional modules. Participants who received at least one dose of  
20 the COVID-19 vaccine were categorized as vaccinated. The sample size is 12,514.

21 Results. Participants who were female (OR=1.35, 95% CI: [1.19,1.52]), greater than or  
22 equal to 65 years old (OR=4.76, 95% CI: [3.82,5.93]), and graduated college (OR=4.18,  
23 95% CI: [3.26,5.34]) had higher odds of receiving at least one dose of the COVID-19  
24 vaccine. After adjustment, ACEs scores were found not to be significantly associated  
25 with COVID-19 vaccination status (AOR= 0.99, 95% CI: [0.86,1.13]).

26 Conclusion. The association between COVID-19 vaccine uptake and ACEs scores may  
27 be accounted for by factors other than socioeconomic factors. Differences in COVID-19  
28 vaccine uptake between females and males could be influenced by proactive lifestyle  
29 health behaviors.

## 30 **Introduction**

31 ACEs (Adverse Childhood Experiences) represent events early in life that can affect an  
32 individual's health later in life. These are considered childhood experiences that were  
33 potentially traumatic and had negative consequences during childhood and can be  
34 attributed to maltreatment and abuse within a living environment<sup>1</sup>. The questionnaires  
35 related to ACEs were initially developed by the Centers for Disease Control and  
36 Prevention (CDC) in 1998 in conjunction with Kaiser-Permanente to investigate the  
37 major three components of childhood adverse experiences: abuse, household  
38 challenges, and neglect<sup>1</sup>. A recent study has shown that ACEs directly impact  
39 individuals via abuse, neglect, and how their living environment is shaped (e.g., parental  
40 conflict or mental illness)<sup>2</sup>. Through physiological developmental factors, individuals with  
41 ACEs increase their susceptibility to disease development and health-damaging  
42 behaviors<sup>2,3</sup>. An association between graded ACEs and adolescents' mental health has  
43 been established, with high ACEs scores being documented in individuals with mental  
44 health conditions<sup>3</sup>. A study from 2017 showed that as ACEs scores increased, the odds  
45 of experiencing suicide attempts, use of alcohol, and depression also increased<sup>4</sup>. A  
46 significant predictor of a high ACEs score across the board was child sexual abuse,  
47 which highlights such effects in adult outcomes<sup>4</sup>. Specific demographics are at higher  
48 risk of vulnerabilities, including multiracial people, younger adults, females, and sexual  
49 minorities<sup>3</sup>. A 2021 study in Delaware found similar findings with Lesbian, Gay, Bisexual,  
50 Transgender, and Queer (LGBTBQ) adults having a high prevalence of ACEs with a  
51 score greater than or equal to three<sup>5</sup>.

52 Socioeconomic factors play a determining role in childhood adverse events. Individuals  
53 with higher income and college degrees exhibited lower mean ACE scores than those  
54 with lower income, such as only high school-educated individuals<sup>6</sup>. Unemployed  
55 individuals showed higher ACE mean scores when compared to those who were  
56 employed<sup>6</sup>.

57

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59 The COVID-19 pandemic, which spread rapidly in the U.S., signified the beginning of a  
60 long fight to vaccinate as many people as possible. Immunization programs often target  
61 the most vulnerable and teach Americans about vaccine safety to prevent further spread  
62 of infections. A study in Wales from December 2020 to March 2021 showed that  
63 individuals with higher ACE counts were more likely to have low trust in the COVID-19  
64 vaccine and other general information related to the virus<sup>10</sup>.

65 However, not all vaccines have a positive correlation with higher ACE scores. A study  
66 regarding HPV vaccination in young adults aged 18-29 shows that several categories of  
67 ACEs, such as sexual abuse, were positively associated with HPV vaccination<sup>5</sup>.  
68 However, the study's findings suggest that this association was not likely caused by  
69 preventative health measures or access to health care<sup>5</sup>. A retrospective analysis of  
70 gender-based differences in influenza immunization from 2018-2019 showed that  
71 influenza vaccination was more likely among females (62.8%) when compared to males  
72 (53.2%)<sup>7</sup>. These gender differences, however, are not reflected in the COVID-19  
73 vaccine. A study published in July 2021 showed that females are more likely to have  
74 mistrust in the safety of the COVID-19 vaccine by an even wider margin (59.2% females  
75 vs. 38.5 % males)<sup>8</sup>. Social inequities have been associated with vulnerability to COVID-  
76 19<sup>9</sup>, but the relationship between ACEs and the COVID-19 vaccine has not been  
77 thoroughly researched. A study from 2021 concluded that young adults were more  
78 unwilling to receive the COVID-19 vaccine, but the findings were not representative of  
79 COVID-19 uptake<sup>9</sup>. Such findings could represent the potential gap that exists between  
80 COVID-19 vaccine hesitancy and actual uptake of the vaccine in the younger  
81 generations.

82 The 2022 BRFFS survey questionnaire compiles questions about the participant's recall  
83 of childhood events. These questions were given to adults older than 18 who were  
84 asked to recall any likely traumatic experience early on in life. The objective is to assess  
85 the relationship between ACEs and receiving at least one dose of the COVID-19  
86 vaccine. Using at least one dose as a measurement of immunization is based on a  
87 study of ACEs conducted in Wales in 2020 in which individuals who identified their

88 responses with a 'no' were categorized as the group that did not receive the COVID-19  
89 vaccine<sup>10</sup>.

## 90 **Methods**

### 91 Study Design

92 A cross-sectional study design from surveyed data was used for this study. Data from  
93 2022 were collected using the Centers for Disease Control and Prevention (CDC)  
94 Behavioral Risk Factor Surveillance System (BRFSS)-which surveys  
95 noninstitutionalized adults 18 years and older on health and risk behaviors in all 50  
96 states, the District of Columbia, and other U.S territories. The BRFSS conducts both  
97 landline and cellular telephone-based surveys, and interviewers are randomly selected  
98 from a household. For 2022, individuals with cellular telephone samples who resided in  
99 private residences or colleges were included<sup>10</sup>. Included in the optional module for 2022  
100 are data related to ACEs. A total of 12 States were included in this module. The BRFSS  
101 ACE module includes 13 questions that are categorized into eight categories with  
102 adverse experiences. The other optional module used in the study was the COVID-19  
103 module which includes questions related to COVID-19 infections and potential health  
104 effects. A total of 30 states were included in this module. The data used combines the  
105 core and optional modules which require reweighting the data to reduce potential bias  
106 and noncoverage of segments of the population. This process of reweighting the data is  
107 due to potential differences on a state-by-state basis when conducting surveys in  
108 different states in addition to compensating for non-response<sup>10</sup>. Design weight allows for  
109 the collection of sample data that is more representative of the population<sup>10</sup>. The  
110 weighing methodology consists of design factors and demographic adjustment of the  
111 population by either iterative proportional fitting or raking<sup>11</sup>. The stratum weight is used  
112 to account for differences among strata (are codes or prefix combinations)<sup>10</sup>.

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## 116 Study Population

117 Participants who answered all the questions related to ACEs and COVID-19 vaccine  
118 uptake were included in the study. Participants who answered “refuse”, “don’t know” or  
119 “missing” for any of the questions relating to the outcome and exposure were excluded.  
120 Individuals less than 18 years old were excluded from the study since the BRFSS  
121 questionnaire is only administered to adults 18 years or older. The available study  
122 population consisted of 29,854 and the sample population consisted of 12,514 after  
123 exclusion criteria was established. The degree of missingness was 58%.

## 124 COVID-Vaccination

125 Data for COVID-19 vaccination status were obtained from the optional module in the  
126 BRFSS 2022. To assess COVID-19 vaccination status, participants were asked whether  
127 they had received at least one dose of the COVID-19 vaccine. Participants who  
128 received at least one dose of the COVID-19 vaccine were designated as the reference  
129 group.

## 130 Adverse Childhood Experiences (ACEs)

131 Data for ACEs was obtained from an optional module in the BRFSS 2022. The module  
132 consists of 13 questions related to childhood experiences which occurred before the  
133 age of 18. Responses of “Don’t Know” or “Refused” were coded as missing. The range  
134 for the final score was (0-13), which is dichotomized into two groups: 0-2 and  $\geq 3$ . An  
135 ACE score of 0-2 is considered “low-risk” and a score of  $\geq 3$  is considered “high-risk”.  
136 This method of categorical grading is consistent with a study in Delaware that studied  
137 the association between ACE scores and other chronic health conditions<sup>2</sup>. The method  
138 for scoring and categorizing was verified externally from a study that differentiates  
139 between “low risk” and “high risk” in a grading system<sup>9</sup>.

## 140 Measures

141 Demographic variables were obtained from the core BRFSS 2022 module. Age was  
142 grouped as follows: 18-24,25-34,35-44,45-54,55-64, and 65 or older. Sex was  
143 categorized into two groups: male and female. Race was categorized into four groups:

144 White non-Hispanic, Black non-Hispanic, Hispanic, and Other Race/Ethnicity which  
145 included respondents who reported being Pacific Islanders, Native Hawaiian, American  
146 Indian or Alaskan Native only, and Multiracial. Education was categorized into four  
147 groups: Not a High School Graduate, High School Graduate, Some College, and  
148 College Graduate. Income was grouped as follows: Less than \$50,000, \$50,000 to less  
149 than \$100,000, \$100,000 or more, and missing. Due to the high degree of missing data  
150 in the income group, participants who did not report income were grouped as “Missing”.  
151 Health insurance was grouped into two groups: Have insurance and No Health  
152 Insurance.

### 153 Statistical Analyses

154 Using weighted univariate analyses, participant characteristics were analyzed to  
155 explore underlying data distribution in the study population. Distribution of ACEs scores,  
156 COVID-19 vaccination status, and covariates were calculated. To assess the  
157 relationship between two variables, logistic regression was used to analyze the crude  
158 association between ACE score and receiving at least one dose of the COVID-19  
159 vaccine. Covariates were also individually analyzed for a relationship with the exposure  
160 and outcome using binary logistic regression. Multivariate logistic regression was used  
161 to examine the association between ACES and COVID-19 vaccine status after adjusting  
162 for sex, education, age, race, income, and health insurance. A backward elimination  
163 process was used to eliminate potential variables that were not statistically significant. A  
164 threshold p-value of 0.05 was used for the level of significance. All covariates were  
165 found to be statistically significant; and therefore, kept in the final model. Data analyses  
166 were conducted using SAS Studio version 3.82 (SAS Institute, Cary, NC).

### 167 **Results**

168 A total of 12,514 participants responded to the ACE module, COVID-19 vaccination  
169 status, and the demographic covariates in the survey. A total of 9,955 (75.3%)  
170 respondents received at least one dose of the COVID-19 vaccine. Table 1 shows the  
171 self-reported demographic characteristics of the participants as well as the outcome and  
172 exposure distribution. There was a higher proportion of respondents who were White  
173 (81.0%), 65 years or older (27.9%), and with health insurance (93.9%). There were

174 similarities found in the distribution of sex: Male (50.5%) and female (49.5%). In terms  
175 of income, individuals making less than \$50,000 were the largest proportion in the study  
176 group (36.4%).

177 Table 2 shows the distribution and weighted odds ratio of patient demographic variables  
178 by vaccination status. Respondents who received at least one dose of the COVID-19  
179 vaccine had 31% lower odds of having an ACEs score of three or greater versus those  
180 who did not receive the COVID-19 vaccine (OR=0.69, 95% CI: [0.60,0.78]). Females  
181 had 35% higher odds of having received at least one dose of the COVID-19 vaccine  
182 when compared to males (OR=1.35, 95% CI: [1.19,1.52]). Black non-Hispanic  
183 respondents had 16% higher odds of having received the vaccine when compared to  
184 White-Non-Hispanic (OR=1.16, 95% CI: [0.84,1.61]). Other Race/Ethnicity respondents  
185 had 7% lower odds of having received at least one dose of the COVID-19 vaccine when  
186 compared to White non-Hispanic respondents (OR=0.93, 95% CI: [0.69,1.25]).

187 Respondents 65 years or older had 4.74 higher odds of having received at least one  
188 dose of the COVID-19 vaccine when compared to the 18-24 age group (OR=4.74, 95%  
189 CI: [3.82,5.93]). Respondents aged 55-64 had 89% higher odds of having received at  
190 least one dose of the COVID-19 vaccine when compared to the 18-24 age group  
191 (OR=1.89, 95% CI: [1.47,2.42]). College graduates had 4.18 higher odds of having  
192 received at least one dose of the COVID-19 vaccine when compared to respondents  
193 who did not graduate High school (OR=4.18, 95% CI: [3.26,5.34]).

194 Respondents who earned \$100,000 or more had 55% higher odds of having received  
195 at least one dose of the COVID-19 vaccine when compared to those who earned less  
196 than \$50,000 (OR=1.55, 95% CI: [1.31,1.82]). Respondents who reported having health  
197 insurance had 3.21 higher odds of having received at least one dose of the COVID-19  
198 vaccine when compared to those with no health insurance (OR=3.21, 95% CI:  
199 [2.48,4.15]).

200 Table 3 shows the distribution and unadjusted weighted odds ratio of patient  
201 demographic variables by ACE categorical score. Respondents who received at least  
202 one dose of the COVID-19 vaccine had 31% lower odds of having a high-risk ACEs  
203 score when compared to those who did not receive the vaccine (OR=0.69, 95% CI:



204 [0.60,0.79]). Males had a 13% decrease in odds of having a high-risk ACEs score when  
205 compared to females (OR=0.87, 95% CI: [0.78,0.96]). Respondents in the Other  
206 Race/Ethnicity category had 62% higher odds of having a high-risk ACEs score when  
207 compared to White-non-Hispanic (OR=1.62, 95% CI: [1.22,2.15]). Black non-Hispanics  
208 had 42% higher odds of having a high-risk ACEs score when compared to White-non-  
209 Hispanic (OR=1.42, 95% CI: [1.09,1.86]). Participants 65 years or older had 69% lower  
210 odds of having a high-risk ACEs score when compared to the 18-24 age group  
211 (OR=1.62, 95% CI: [1.22,2.15]).

212 In terms of education, participants who graduated college had 18% lower odds of  
213 having a high-risk ACEs score when compared to those who had some college  
214 education (OR=0.72, 95% CI: [0.64,0.80]). Respondents who earned \$100,000 or more  
215 had 20% lower odds of having a high-risk ACEs score when compared to those  
216 respondents who earned less than \$50,000 (OR=0.80, 95% CI: [0.70,0.91]).

217 Respondents who reported missing income had 33% lower odds of having a high-risk  
218 ACE score when compared to those respondents who earned less than \$50,000  
219 (OR=0.67, 95% CI: [0.57,0.79]). Respondents who reported having health insurance  
220 had 33% lower odds of having a high-risk ACE score when compared to those  
221 respondents who reported not having health insurance (OR=0.71, 95% CI: [0.54,0.93]).

222 Results from Table 4 show multivariate analyses. Results are presented as the  
223 association between ACE categorical scores and COVID-19 vaccination status after  
224 adjusting for potential confounders, age, race, sex, education, health insurance, and  
225 income. Categorical ACE scores were found not to be significantly associated with  
226 COVID-19 vaccination status after adjusting for selected covariates. Females had 19%  
227 lower odds of receiving at least one dose of the COVID-19 vaccine after adjusting for  
228 selected variables (AOR=1.19, 95% CI: [1.04,1.36]). Hispanics had 2.47 higher odds of  
229 having received at least one dose of the COVID-19 vaccine after adjusting for ACE  
230 categorical score and selected covariates when compared to White-Non-Hispanic  
231 (AOR=2.47, 95% CI: [1.73,3.53]). Black non-Hispanics had 93% higher odds of having  
232 received at least one dose of the COVID-19 vaccine after adjusting for ACE categorical

233 score and demographics when compared to White non-Hispanics (AOR=1.93, 95% CI:  
234 [1.35,2.76]).

235 Respondents in the 65 years and older group had 4.29 higher odds of having received  
236 at least one dose of the COVID-19 vaccine after adjusting for ACE categorical score  
237 and demographics when compared to the 18-24 age group (AOR=4.29, 95% CI:  
238 [3.36,5.47]. Respondents who graduated college had 4.97 higher odds of having  
239 received at least one dose of the COVID-19 vaccine after adjusting for ACE categorical  
240 score and demographics when compared to those respondents who did not graduate  
241 high school (AOR=4.97, 95% CI: [3.67,6.72]).

242 Respondents who earned \$100,000 or more had 40% higher odds of having received  
243 at least one dose of the COVID-19 vaccine after adjusting for ACE categorical score  
244 and demographics when compared to those respondents who earned less than \$50,000  
245 (AOR=1.40, 95% CI: [0.1.15,1.69]). Respondents who reported having health insurance  
246 had 2.01 higher odds of having received at least one dose of the COVID-19 vaccine  
247 after adjusting for ACEs categorical score and demographics when compared to those  
248 respondents who with no health insurance (AOR=2.01, 95% CI: [0.1.51,2.68]).

## 249 **Discussion**

250 No significant association between ACEs and receiving at least one dose of the COVID-  
251 19 vaccine was found. Respondents who earned high-risk ACEs scores were more  
252 likely to have not received at least one dose of the COVID-19 vaccine, consistent with  
253 previous literature<sup>11</sup>. The relationship between traumatic events and rejection of COVID-  
254 19 vaccines is documented in the same study which found a significant difference in  
255 vaccine uptake between those with no ACEs and those with four or more ACEs<sup>11</sup>. The  
256 results of this study were unexpected because previous literature had shown individuals  
257 with high-risk ACEs scores had low trust in public health control measures and the  
258 health system as a whole<sup>11</sup>. This might suggest differences in COVID-19 vaccination  
259 uptake were shaped by more than the demographic factors attributed to this study. For  
260 example, the majority of respondents reported having health insurance, which may  
261 suggest a proactive view of their health behaviors.

262 The results of the study suggest socioeconomic factors may only play a small role in the  
263 relationship between COVID-19 vaccine uptake and ACEs scores. As highlighted by  
264 previous literature, age and gender play a role in the health behaviors associated with  
265 the decision-making processes regarding an individual's health<sup>5</sup>. Younger generations  
266 showed higher odds of high-risk ACEs scores and a decrease in the odds of COVID-19  
267 vaccination. This could be explained by generation differences in exposure to ACEs or  
268 could demonstrate that ACEs may be increasing, as shown by recent literature<sup>5,6</sup>.

269 ACEs were prominently found in American adults with 60% of adults having a least one  
270 unique ACE<sup>12</sup>. Nearly half of the study population was found to have a high-risk score,  
271 regardless of vaccination uptake. Differences in vaccine uptake could be related to  
272 external factors that extend beyond childhood experiences and socioeconomic  
273 attributes. Assessing the role of ACEs scores in vaccination status requires an  
274 understanding of potential differences in how ACEs impacted them over time.  
275 Differences in how each respondent recalls potential physical and emotional events  
276 may change the future long-term outlook of their health behaviors. Females exhibited  
277 higher odds of receiving the vaccine and high-risk ACEs scores. Oppositely, males  
278 exhibited higher odds of a low-risk ACE score and lower odds of receiving the vaccine.  
279 Such contrast highlights differences in health behaviors in both sexes.

280 COVID-19 vaccination in minority populations showed differences in health behaviors  
281 as it relates to COVID-19 vaccine uptake. Differences in COVID-19 vaccine uptake can  
282 be explained by the disproportionate effects of the COVID-19 pandemic on Black  
283 individuals which increased COVID-19 vaccine uptake in this group<sup>13</sup>. The study,  
284 however, did show a differentiating contrast in high-risk ACEs scores in Blacks versus  
285 Whites, which might suggest health behaviors are based on present experience rather  
286 than recollection of past childhood events. Although the COVID-19 vaccine is relatively  
287 new, research has found acceptance of this vaccine among Hispanics<sup>14</sup>. Potential  
288 differences in ACEs scores among racial groups could be explained by differences in  
289 vulnerabilities and their living environment<sup>2</sup>. Differences in COVID-19 vaccine uptake in  
290 minority populations could suggest increased vaccination accessibility and culturally  
291 tailored educational campaigns to increase the uptake in these communities<sup>15</sup>.

292 Accessing how ACEs affect COVID-19 vaccination uptake could require an  
293 understanding of differences on an individual basis and the dose-response factor of this  
294 association.

#### 295 Limitations

296 Only casual conclusions can be drawn from the BRFSS survey and its ability to associate  
297 ACEs scores and COVID-19 vaccine uptake. The survey limits itself to non-  
298 institutionalized participants, which limits access to individuals who don't have a  
299 household. The data is weighted heavily towards individuals who were in the older  
300 generations, which could underrepresent the younger generations. Potential biases may  
301 affect the reliability of the results from the use of retrospective self-reports and the  
302 underestimation of ACEs scores due to problems with recall and willingness to recall  
303 traumatic experiences among the older generation. Women with low-risk ACEs scores  
304 could have difficulty recalling traumatic events, especially of a sexual nature. This could  
305 have underrepresented the high-risk ACEs group. The duration of the severity of each  
306 ACEs question cannot be quantitated and is limited to its capacity<sup>5</sup>. The dichotomization  
307 of ACEs scores limits the ability of the study to assess potential differences between  
308 individuals with no ACEs versus those who had a high-risk ACEs score. The degree of  
309 missingness resulting from exclusion/inclusion criteria was relatively high at 58%. This  
310 may lead to bias as it may have excluded individuals who may have been representative  
311 of the exposure-outcome relationship. A potential issue of the cross-sectional design of  
312 the study is the concept of temporality and the difficulty in determining if the exposure is  
313 established before the outcome. Additionally, the findings of the study may not be  
314 generalizable to the general population due to potential biased sampling selection  
315 methods.

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320 **Public Health Importance**

321 Attention should be directed at the modifiable risks that ACEs pose among females who  
322 have experienced past trauma. Mitigating poor outcomes requires an intervention and  
323 resources directed at the most vulnerable young adults. In particular, a more practical  
324 approach of reaching the younger population and teaching them the importance of  
325 vaccines. A long-term study such as a longitudinal study, would follow the young  
326 cohorts throughout their lifespan to identify vulnerabilities to high-risk ACEs scores and  
327 vaccine uptake status. This research can also help address some of the stigma around  
328 young racial minorities and vaccine uptake in the long term.

329 Development of intervention and prevention efforts directed at males would help  
330 decrease some of the health disparities that exist as it relates to the COVID-19 vaccine  
331 uptake. Emphasizing the independent effects of COVID-19 stressors on young males  
332 and their resistance to vaccines is important from a policy point of view. Assessing the  
333 gaps that exist in ACEs scores among socioeconomic groups should be a priority using  
334 a targeted health approach. Particular attention should be directed to the young, lower  
335 socioeconomic-status, female individuals due to the high prevalence of ACEs in this  
336 population.

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348 **Table 1. Self-reported distribution of COVID-19 vaccine status, ACE Scores, and**  
 349 **patient demographics: 2022 Behavioral Risk Factor Surveillance System Surveys**

Characteristic	No. of Participants, n=12,514 (adjusted%)
Received at least one dose of COVID-19 vaccine	
Yes	<b>9955 (75.3)</b>
No	2559( 24.7)
ACE score	
0-2	5262 (35.8)
>=3	<b>7252 (64.2)</b>
Sex	
Male	5988 (49.0)
Female	5261 (51.0)
Race/Ethnicity	
White, non-Hispanic	<b>10828 (81.0)</b>
Black, non-Hispanic	500 (7.0)
Hispanic	705 (6.0)
Other Race/Ethnicity	481 (6.0)
Age	
18-24	933 (13.4)
25-34	1356 (17.7)
35-44	1558 (17.0)
45-54	1833 (15.6)
55-64	1159 (8.4)
>=65	<b>5509 (27.9)</b>
Education	
Did not Graduate High School	728 (8.2)
High School Graduate	3658 (31.5)
Some college	<b>3599 (33.5)</b>
College Graduate	4529 ( 26.8)
Income	
Less than \$50,000	<b>4577 (36.4)</b>
\$50,000 to \$100,000	3591 (28.4)
\$100,000 or more	2490 (20.5)
Missing	1856 (14.7)
Health Insurance	
Had Health Insurance	<b>11531 (93.9)</b>
No Health Insurance	531 (6.1)

350 Abbreviation: ACE: adverse childhood experiences, No.: Number, n=sample size

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352 **Table 2. Prevalence and adjusted odds ratio for ACEs scores, sex, race, age,**  
 353 **education, income, and health insurance by COVID-19 vaccination status: 2022**  
 354 **Behavioral Risk Factor Surveillance System Surveys n=12,514**

Variable	Did not receive COVID-19 vaccine n (adjusted %)	COVID-19 vaccine (%) Received COVID- 19 vaccine n (adjusted %)	Odds ratio (95% CI)
ACES score			
0-2	899 (30.2)	4363 (37.6)	REFERENCE
>=3	1660 (69.8)	5592 (62.4)	<b>0.69(0.60,0.78)</b>
Sex			
Male	1406 (54.6)	4582 (47.2)	REFERENCE
Female	1153 (45.4)	5373 (52.8)	<b>1.35(1.19,1.52)</b>
Race/Ethnicity			
White non-Hispanic	2193 (81.3)	8635 ( 80.8)	REFERENCE
Black non-Hispanic	91 (6.3)	409 (7.3)	<b>1.16(0.84,1.61)</b>
Hispanic	165 (6.0)	540 (5.9)	1.00(0.76,1.32)
Other Race/Ethnicity	110 (6.4)	371 (6.0)	0.93(0.69,1.25)
Age			
18-24	326 (18.9)	607 (11.6)	REFERENCE
25-34	464 (25.6)	892 (15.1)	0.96(0.76,1.21)
35-44	509 (20.2)	1215 (16.0)	1.29(1.03,1.61)
45-54	464 (16.4)	1369 (15.3)	1.52(1.21,1.89)
55-64	263 (7.5)	896 (8.7)	1.89(1.47,2.42)
>=65	533 (11.4)	4976 (33.3)	<b>4.76(3.82,5.93)</b>
Education			
No HS graduation	228 (12.2)	500 (6.9)	REFERENCE
HS Graduate	948 (39.7)	2710(28.8)	1.29(1.01,1.64)
Some College	825 (34.8)	2774 (33.1)	1.69(1.33,2.15)
College Graduate	558 (13.3)	3971 (31.2)	<b>4.18(3.26,5.34)</b>
Income			
Less than \$50,000	969 (39.9)	3608 (35.2)	REFERENCE
\$50,000 to <\$100,000	720 (28.0)	2871 (28.5)	1.15(0.99,1.34)
\$100,000 or more	463 (16.1)	2027 (22.0)	<b>1.55(1.31,1.82)</b>
Missing	407 (16.0)	1449 (14.3)	1.02(0.84,1.23)
Health Insurance			
Have Health Insurance	2196 (87.7)	9335 (95.8)	3.21(2.48,4.15)
No Health Insurance	217 (12.3)	314(4.2)	REFERENCE

355 Abbreviations: ACE: adverse childhood experiences, No.: Number, HS: High school,  
 356 CI: confidence interval, n=sample size Level of significance: P<0.05, ACEs derived from  
 357 13 questions.

358 **Table 3. Prevalence and adjusted odds ratio for COVID-19 vaccination, sex, race,**  
 359 **age, education, income, and health insurance by ACE scores: 2022 Behavioral**  
 360 **Risk Factor Surveillance System Surveys n=12,514**

Variable	ACE Scores		Odds ratio (95% CI)
	ACE score 0-2 (adjusted %)	n ACE score >=3 n(adjusted %)	
At least one dose of COVID-19 vaccine			
No	899(20.9)	1660(26.9)	REFERENCE
Yes	4363(79.1)	5592(73.1)	<b>0.69(0.60,0.79)</b>
Sex			
Male	2571(51.3)	3417(47.7)	<b>0.87(0.78,0.96)</b>
Female	2691(48.7)	3835(52.3)	REFERENCE
Race/Ethnicity			
White-non-Hispanic	4684(84.4)	6144(79.0)	REFERENCE
Black, non-Hispanic	181(5.8)	319(7.7)	<b>1.42(1.09,1.86)</b>
Hispanic	258(5.3)	447(6.3)	<b>1.28(0.99,1.64)</b>
Other Race/Ethnicity	139(4.5)	342(7.0)	<b>1.62(1.22,2.15)</b>
Age			
18-24	263(9.4)	670(15.6)	REFERENCE
25-34	396(12.6)	960(20.5)	0.98(0.77,1.26)
35-44	566(14.7)	1158(18.4)	0.76(0.60,0.95)
45-54	622(13.5)	1211(16.7)	0.75(0.60,0.95)
55-64	464(9.3)	695(8.0)	0.52(0.41,0.66)
>=65	2558(40.5)	2558(20.8)	<b>0.31(0.26,0.38)</b>
Education			
Did not graduate High School	310(7.5)	418(8.6)	1.07(0.84,1.33)
High School Graduate	1456(29.5)	2202(32.6)	1.02(0.89,1.15)
Some College	1439(31.7)	2160(34.5)	REFERENCE
College Graduate	2057(31.3)	2472(24.3)	<b>0.72(0.64,0.80)</b>
Income			
Less than \$50,000	1788(33.2)	2789(38.2)	REFERENCE
\$50,000 to \$100,000	1495(27.8)	2096(28.6)	0.89(0.79,1.01)
\$100,000 to or more	1039(21.7)	1451(19.9)	<b>0.80(0.70,0.91)</b>
Missing	940(17.3)	916(13.3)	0.67(0.57,0.79)
Health Insurance			
No Health Insurance	186(4.9)	345(6.8)	REFERENCE
Have Health Insurance	4870(95.1)	6661(93.2)	0.71(0.54,0.93)

361 Abbreviation: ACE: adverse childhood experiences, CI: confidence interval, Level of  
 362 significance: P<0.05. ACEs derived from 13 questions.

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364 **Table 4. Multivariate logistic regression of ACE scores and COVID-19 vaccination**  
 365 **status adjusted for age, race, sex, income, health insurance, and education: 2022**  
 366 **Behavioral Risk Factor Surveillance System Surveys n=12,514**

Variable	COVID-19 vaccine	
	Crude Odds Ratio (95% CI)	Adjusted Odds Ratio (95% CI)
ACES score		
0-2	REFERENCE	REFERENCE
>=3	0.69(0.60,0.78)	<b>0.99(0.86,1.13)</b>
Sex		
Male	REFERENCE	REFERENCE
Female	1.35(1.19,1.52)	<b>1.19(1.04,1.36)</b>
Race/Ethnicity		
White-non-Hispanic	REFERENCE	REFERENCE
Black, non-Hispanic	1.16(0.84,1.61)	<b>1.93(1.35,2.76)</b>
Hispanic	0.99(0.76,1.32)	<b>2.47(1.73,3.53)</b>
Other Race/Ethnicity	0.93 (0.69,1.25)	1.35(0.96,1.90)
Age		
18-24	REFERENCE	REFERENCE
25-34	0.96(0.76,1.21)	0.72(0.56,0.94)
35-44	1.29(1.03,1.61)	0.87(0.68,1.11)
45-54	1.52(1.21,1.89)	1.05(0.82,1.35)
55-64	1.89(1.47,2.42)	1.49(1.14,1.95)
>=65	4.76(3.82,5.93)	<b>4.29(3.36,5.47)</b>
Education		
Did not graduate High School	REFERENCE	REFERENCE
High School Graduate	1.29(1.01,1.64)	1.55(1.17,2.05)
Some College	1.69(1.33,2.15)	2.02(1.52,2.69)
College Graduate	4.18(3.26,5.34)	<b>4.97(3.67,6.72)</b>
Income		
Less than \$50,000	REFERENCE	REFERENCE
\$50,000 to <\$100,000	1.15(0.99,1.34)	1.09(0.92,1.28)
\$100,000 to or more	1.55(1.31,1.82)	<b>1.40(1.15,1.69)</b>
Missing	1.02(0.84,1.23)	0.87(0.70,1.08)
Health Insurance		
Have Health Insurance	3.21(2.48,4.15)	2.01(1.51,2.68)
No Health Insurance	REFERENCE	REFERENCE

367 Abbreviations: ACE: adverse childhood experiences, CI: confidence interval, n=-sample  
 368 size, Level of significance: P<0.05. ACEs derived from 13 questions.

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