



Vaccine hesitancy and COVID-19 immunization among rural young adults

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ABSTRACT

Rural young adults may be more averse to receiving a COVID-19 immunization than urban young adults. We aimed to assess differences in COVID-19 vaccine hesitancy for rural, compared with urban, young adults and characterize modifiable factors.

This cross-sectional online survey collected demographic data, vaccination attitudes, and COVID-19 impacts from 2937 young adults, ages 18–26 years, across the western U.S. from October 2020 to April 2021. Rurality was determined by participants' zip code and classified using the rural and urban continuum codes (RUCC). Multivariable logistic regression described adjusted (age, gender, race and ethnicity, being a current student, and month of survey) odds of self-reported intent to receive the COVID-19 vaccination by rurality. Mediation analysis was used to decompose total effects into average direct effects and average causal mediation (indirect) effects.

Rural participants had 40% lower odds than urban participants of intending to receive the COVID-19 vaccine after adjustments (adjusted odds ratio, 0.62 [95% CI, 0.50–0.76]). The direct effect remained ($P < 0.001$), but was mediated by both education (8.3%, $P < 0.001$) and month in which the survey was taken (23.5%, $P < 0.001$). We observed a divergence after December 2020 in vaccination intent between rural and urban young adults that widened over time.

Hesitancy to receive the COVID-19 vaccine was greater among rural, compared with urban young adults, and grew disproportionately after December 2020. Mediation by whether one was a current student or not suggests differences in sources of information for vaccination decision-making, and highlights areas for addressing vaccine hesitancy.

1. Introduction

Coronavirus disease 2019 (COVID-19) vaccine hesitancy (defined as unwillingness or uncertainty about receiving a vaccine) has fluctuated throughout the pandemic as vaccine development has progressed and more information has become available (Daly and Robinson, 2020; Nguyen et al., 2021; Bokemper et al., 2021). Estimates of COVID-19 vaccine hesitancy range from 9 to 46% for U.S. adults, with higher prevalence among racial and ethnic minorities, females, sexual preferences, individuals living in rural areas, those with lower educational attainment, lower incomes, and those who identify as politically conservative (Daly and Robinson, 2020; Nguyen et al., 2021; Fisher et al., 2020; Taylor et al., 2020; Reiter et al., 2020; Szilagyi et al., 2021; Malik

et al., 2020; Ruiz and Bell, 2021; Khubchandani et al., 2021; Nguyen et al., 2021; Pogue et al., 2020; Callaghan et al., 2021; Singh et al., 2021; Zhang et al., 2022). A growing body of evidence suggests living in rural areas and young age are independently associated with COVID-19 vaccine hesitancy and the pandemic has uniquely impacted urban and rural communities; (Cacari Stone et al., 2021) however, information about the interrelationship of these characteristics is lacking (Khubchandani et al., 2021). Individuals living in rural communities are at an increased risk of severe illness from COVID-19 due to the higher prevalence of underlying health problems (Garcia et al., 2019); higher prevalence of disabilities (Zhao et al., 2019); higher prevalence of uninsured individuals, and limited access to healthcare (Cromartie et al., 2020); With the introduction of the COVID-19 vaccine, the opportunity to intervene and

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prevent worsening health outcomes associated with COVID-19 is essential.

Our project aimed to assess differences in COVID-19 vaccine hesitancy for rural, compared with urban, young adults and characterize modifiable factors for health care professionals, policy makers, researchers and future interventions. Social Cognitive (SCM) and Health Belief (HBM) Models offer a particularly helpful framework for examining health behaviors and vaccine acceptance by accounting for perceived severity, susceptibility, and self-benefit (SCM), in conjunction with self-efficacy and social environment (HBM) (Wilson et al., 2016; Bandura, 2001). We hypothesized that COVID-19 vaccine hesitancy was different for rural young adults, compared with urban young adults, and that the association was mediated by whether the participant was a current student and in what month the participant took the survey.

At a Glance

We surveyed 2937 young adults (ages 18–26 years), from October 2020 – April 2021, and gathered data on demographics, vaccination attitudes, and COVID-19 attitudes. Young adults living in rural areas had 40% less odds of intending to receive a COVID-19 vaccination, compared with urban young adults, a significant difference. Vaccination intent between rural and urban young adults diverged and widened from December 2020 to April 2021, whereas prior (October to December 2020), intent had been narrowing. Even if a health care provider recommended the COVID-19 vaccine, rural young adults indicated that they would be unlikely to receive it at significantly higher frequencies, compared with urban young adults (24% vs 7%, $P < 0.001$). Being a current student partially mediated the association between rurality and COVID-19 vaccination intent, suggesting differences in information sources and access, highlighting modifiable factors for future interventions.

2. Methods

2.1. Participants

The focus of this study was vaccination attitudes and hesitancy among young adults living in the western U.S. Participants who were 18–26 years old, who lived in a western U.S. state (Alaska, Arizona, California, Colorado, Idaho, Montana, New Mexico, Nevada, Oregon, Utah, Washington, or Wyoming), who gave voluntary consent, and who had access to the internet-based survey via a computer, or web-enabled phone, were considered eligible for inclusion. This study was approved by the University of Utah IRB (00110831) and participants were informed of the voluntary and investigative nature of the study. Inclusion and exclusion criteria are further described below and in Fig.A.1.

2.2. Study design and recruitment

A cross-sectional survey, evaluating vaccine hesitancy within the context of the COVID-19 pandemic, was distributed to young adults living in the western U.S. Participants self-reported COVID-19 vaccine intention, impact of the pandemic on lifestyle and mental health, in addition to sociodemographic information. Survey design was based on our previous work and framed within the SCM and HBM (Wilson et al., 2016; Bodson et al., 2017).

The survey was self-administered from October 2020 to April 2021. Participants were recruited using ResearchMatch.org, Exact Data list servs, University of Utah list servs, Brigham Young University list servs, and Intermountain West HPV Vaccination Coalition list servs. Study data was collected and managed using Research Electronic Data Capture (REDCap) tools hosted by University of Utah Center for Clinical Translational Science. Qualtrics services were utilized to oversample rural populations in the study area, beginning in March 2021 and ending April 2021. Qualtrics emailed survey invitations, to members, who had previously given permission to be contacted, using an anonymous link and self-administered online. Qualtrics hosted and managed the survey, which closed when 1,059 responses, that met inclusion criteria (residence in a rural zip code in the study area and age eligible) were

collected.

Although Captcha verification was employed, participation was incentivized (first 500 responses received a \$10 Amazon.com eGift card) and many fraudulent responses were collected. Quality control for fraudulent responses from surveys collected using REDCap (Harris et al., 2019; Harris et al., 2009) excluded all participants with duplicate IP-addresses that were also, missing free-text responses, or had identical free-text responses within a single survey. Qualtrics data also suffered from internet bots and duplicate responses, which were subsequently removed. Only participants who consented, completed the survey, were 18–26 years old, reported a residential zip code within a western U.S. state, and met quality control measures were included in analyses (Fig. A.1). Overall, 7,052 participants began the survey with a completion rate of 86.8%, and quality control measures resulted in a final sample size of $n = 2,937$ (41.6%).

2.3. Measurements, outcomes, and covariates

2.3.1. COVID-19 vaccine hesitancy (Outcome)

COVID-19 vaccine intent was dichotomized as “yes” or “no/unsure” based on participants response (yes, no, or don’t know/unsure) to the question: “When a COVID-19 vaccine becomes approved and available do you plan to get vaccinated?” The survey began in October 2020, prior to the release of a COVID-19 vaccine; hence, the survey instrument did not include a question about obtainment of the vaccine, only intention to attain the vaccine.

2.3.2. Rurality (Exposure)

Rurality was measured using the Rural Urban Continuum Codes (RUCC) based on participants’ self-reported zip code. RUCC classifies counties as rural or urban based on population size, degree of urbanization, and adjacency to a metro area (Cromartie and Bucholtz, 2008; Documentation, 2017). We defined urban areas as counties with $RUCC < 4$ and rural areas as $RUCC \geq 4$. The U.S. Department of housing and urban development’s (HUD) crosswalk files (Wilson and Din, 2018) were employed to relate zip code to county geographies, and because the boundaries overlap (a many-to-many relationship), zip codes that included both urban and rural counties (i.e., spatially heterogeneous areas), were classified as “mixed”, similar to Waldorf (Waldorf, 2006).

2.3.3. Covariates

Age was collected as a continuous variable from 18 to 26. Participants chose from either “female,” “male,” or “other” to identify their gender. Participants chose from White/Caucasian, Black or African American, Asian or Asian American, American Indian/Alaska Native, Pacific Islander/Native Hawaiian, or Mixed-Race to identify their race. Ethnicity was determined based on how participants responded (yes or no) to the question “Are you Hispanic or Latino?” Race and ethnicity were combined to create three groups: Non-Hispanic White/Caucasian, Non-Hispanic Minority Race, and Hispanic/Latino. Participants were asked if they were ‘currently a student’ (yes or no) and what category best described their ‘classification in college’ (Freshman/first year, Sophomore, Junior, Senior, Graduate, Postgraduate, or Other). Each survey was time stamped (YYYY-MM-DD HH:MM:SS) by the system, and month of survey was extracted for examination of changes over time. Vaccination attitudes and COVID-19 impacts by rurality were examined using questions about provider-recommendations, concern about the virus, self-isolation practices, and impacts of the pandemic and lifestyle, and mental health.

2.4. Statistical analysis

Sample size planning for our study was based on using logistic regression for estimating odds of intending to receive a COVID-19 immunization (yes or no/unsure) and rurality (urban, rural, or mixed). We calculated that at least 75 individuals in each stratum were needed in

order to detect rates of intent to vaccinate by +/- 20% (i.e., differing by a factor of > 1.2 or < 0.70) and test the association at a 5% significance level, using a two-sided test, with power > 80%. The power calculation was carried out using R programming WebPower library.

Descriptive analyses were performed by calculating frequencies for categorical data, and medians with interquartile ranges (IQR) for continuous data. Comparative analyses by rurality (urban, rural, or mixed) were performed using Wilcoxon rank-sum test for continuous variables, favored over t-tests due to relaxed normality assumptions, and Pearson Chi-squared test of independence for categorical variables. Multivariable logistic regression estimated odds of intending to receive a COVID-19 immunization with 95% confidence intervals. Covariates used for model adjustments (age, gender, race and ethnicity, student status, and time of survey) were created using a Structural Causal Model, as proposed by Pearl (Pearl, 1995; Pearl, 2009; Pearl, 2009; Pearl, 2000); via a directed acyclic graph (DAG), using DAGitty (Textor et al., 2016); which visually encoded both researcher prior knowledge, and the data generating process.

To ensure spurious associations, created by conditioning on a mediator, were not interpreted as direct effects, we employed causal mediation analysis to decompose total effects into average direct effects (ADE), and average causal mediation (indirect) effects (ACME). The dataset used for mediation analysis (n = 2889) included surveys from participants that did not have any missing data for any of the covariates included in the regression model and was performed using nonparametric bootstrapping over 1000 simulations. We examined both month in which the survey was taken, and whether a participant was a current student, with confounder control for mediation as single mediator models. Proportion mediated was calculated as a ratio of ACME to the total effect. Additionally, we tested for effect measure modification (EMM) by including interaction terms between the exposure (rurality) and each covariate included in the model. Wald Chi-squared tests of interaction terms were examined for EMM by the interaction terms. Hypothesis testing was 2-sided and analyses were performed using RStudio software (Version 4.0.3 on a 64-bit platform) with various packages: Hmisc, readr, tidyverse, gmodels, lattice, knitr, boot, ggthemes, extrafont, RColorBrewer, gt, gtsummary, survey, glue, foreign, nnet, reshape2, flextable, aod, mediation, lme4, afex, dplyr, ggplot2, and forecast. Microsoft Excel and Visio (Professional plus 2019) were utilized for figure creation.

3. Results

3.1. Demographic characteristics

As shown in Table 1, rural residents (RUCC \geq 4) were well represented (39%) within our study population, which was predominantly female (69%), non-Hispanic white (NHW) (65%), self-identified as a current student (67%), had a median age of 22 (IQR: 20–24), and had some form of insurance beyond single service (e.g., dental, vision, or prescriptions) (80%). Most demographic characteristics differed significantly ($P < 0.001$) by intent to obtain the COVID-19 vaccine. Those indicating they intended to obtain a COVID-19 vaccination tended to be older (median age of 22 (Wilson et al., 2016; Bandura, 2001; Bodson et al., 2017; Harris et al., 2019; Harris et al., 2009) vs. 21 (Cromartie et al., 2020; Wilson et al., 2016; Bandura, 2001; Bodson et al., 2017; Harris et al., 2019; Harris et al., 2009), current students (71% vs. 60%), had income greater than \$40,000 annually (39% vs. 30%), had health insurance (85% vs. 71%), and lived in metro areas (62% vs. 31%). A significant difference in vaccination intent by month in which the survey was taken ($P < 0.001$) was observed, whereby the percent-point difference between intent of “yes” and “no or unsure” decreased from the beginning (October 2020, +7 points) to end (April 2021, -4 points) of the study. Additionally, we observed vaccination intent differed for both rural and urban young adults by the month in which the survey was taken ($P < 0.001$), but that intent only differed significantly by self-

Table 1

Participant characteristics by COVID-19 vaccination intentions, among young adults (ages 18–26 years) in the western U.S., October 2020 – April 2021.

| | All ¹ | COVID-19 Vaccine Intent ¹ | | p-value ² |
|---|------------------|--------------------------------------|-------------------------|----------------------|
| | N = 2,937 | Yes, N = 1,840 | No/Unsure, N = 1,097 | |
| Age (years), Median (IQR) | 22 (20 – 24) | 22 (20 – 24) | 21 (19 – 24) | <0.001 |
| Gender, n (%) | | | | 0.12 |
| Female | 2,040 (69) | 1,256 (68) | 784 (71) | |
| Male | 849 (29) | 556 (30) | 293 (27) | |
| Other | 48 (1.6) | 28 (1.5) | 20 (1.8) | |
| Race & Ethnicity, n (%)³ | | | | 0.019 |
| Non-Hispanic White/Caucasian | 1,892 (65) | 1,180 (65) | 712 (67) | |
| Non-Hispanic Minority ³ | 504 (17) | 344 (19) | 160 (15) | |
| Hispanic/Latinx | 493 (17) | 297 (16) | 196 (18) | |
| Student, n (%) | | | | <0.001 |
| No | 974 (33) | 538 (29) | 436 (40) | |
| Yes | 1,963 (67) | 1,302 (71) | 661 (60) | |
| Classification in College, n (%)⁴ | | | | 0.047 |
| Freshman | 480 (22) | 284 (20) | 196 (25) | |
| Sophomore | 365 (17) | 230 (16) | 135 (17) | |
| Junior | 413 (19) | 271 (19) | 142 (18) | |
| Senior | 484 (22) | 331 (24) | 153 (19) | |
| Post-grad/Graduate | 456 (21) | 288 (21) | 168 (21) | |
| Time of Survey, n (%) | | | | <0.001 |
| October | 724 (25) | 502 (27) | 222 (20) | |
| November | 166 (5.7) | 122 (6.6) | 44 (4.0) | |
| December | 585 (20) | 455 (25) | 130 (12) | |
| January | 201 (6.8) | 121 (6.6) | 80 (7.3) | |
| February | 135 (4.6) | 77 (4.2) | 58 (5.3) | |
| March | 731 (25) | 343 (19) | 388 (35) | |
| April | 395 (13) | 220 (12) | 175 (16) | |
| Income, n (%) | | | | <0.001 |
| \$0 - \$39,999 | 1,886 (64) | 1,114 (61) | 772 (70) | |
| More than \$40,000 | 1,051 (36) | 726 (39) | 325 (30) | |
| Health insurance status, n (%)⁵ | | | | <0.001 |
| Insured | 2,339 (80) | 1,563 (85) | 776 (71) | |
| Uninsured/Other | 598 (20) | 277 (15) | 321 (29) | |
| Rurality, n (%)⁶ | | | | <0.001 |
| Mixed | 202 (6.9) | 132 (7.2) | 70 (6.4) | |
| Rural | 1,138 (39) | 564 (31) | 574 (52) | |
| Urban | 1,597 (54) | 1,144 (62) | 453 (41) | |

¹ Median (IQR) or Frequency (%).

² Wilcoxon rank-sum test used for continuous variables; Pearson's Chi-squared test of independence used for categorical variables.

³ Missing n = 48 responses. Non-Hispanic Minority group includes those identifying as non-Hispanic and Black (n = 82), Asian (n = 177), American Indian/Alaska Native (n = 84), Pacific Islander/Native Hawaiian (n = 21), or Mixed-race individuals (n = 55).

⁴ Missing n = 739 responses.

⁵ Health Insurance categorized as a binary response as follows: Insured) Private insurance (HMO, parents' insurance), Medicaid, Medicare, Military health care (TRICARE, VA, CHAMP-VA), State sponsored health plan, or Student insurance through your university; and Uninsured) Uninsured/Self-pay, Single service (dental, vision, prescriptions), Don't know, prefer not to answer, or Other.

⁶ Rurality classified by zip code using Rural-Urban Continuum Codes (RUCC); Urban defined as RUCC < 4; Rural defined as RUCC= \geq 4; Mixed defined as zip codes containing both Urban and Rural county RUCCs.

identifying as a current student for rural (**Table A.1**) ($P < 0.001$) and not urban participants.

3.2. COVID-19 vaccination intent

As shown by our DAG (**Fig.A.2**), age, gender, race and ethnicity, student status, and time of survey were included as the minimally sufficient set in our favored model for estimating the effect of rurality on COVID-19 vaccination intent. Our DAG also indicated mediation on the effect through two mediators: status as a current student, and month in which the survey was taken. As shown in **Table 2**, we observed rural young adults had nearly 40% less odds of intending to receive a COVID-19 vaccination, after adjustments (for age, gender, race and ethnicity, student status, and time of survey), compared with their urban counterparts (aOR, 0.62 [95% CI, 0.50–0.76]). We decomposed the effect estimate to consider the effect through the two mediators apart from the ADE of rurality on vaccination intent.

Mediation analysis with confounder adjustments, shown in **Fig.A.3**, revealed that the ADE, between rurality and vaccination intent, remained ($P < 0.001$), after accounting for the ACME of time of survey, and status as a current student. We observed consistency in both mediation models, whereby ACME and ADE in both the examination of month of survey, and of status as a student, had relationships in opposite directions. As degree of rurality increased (urban, mixed, rural; 0, 1, 2) vaccination intent (no/unsure, yes; 0, 1) decreased from yes to no/unsure. As time progressed, or as status as a current student moved from no to yes (0 to 1), the intent to vaccinate decreased. The proportion of the total effect estimate mediated (i.e., ACME:total effect) by time of survey was an average of 23.5% ($P < 0.001$), and 8.3% was mediated by status as a current student ($P < 0.001$). Of the estimated total effect of rurality on intent to vaccinate (-0.096, $P < 0.001$), an estimated -0.023 ($P < 0.001$) was due to mediation of the relationship through month of survey

(i.e., the mediator) and the remaining -0.073 was due to the ADE of rurality on immunization intent ($P < 0.001$). Distributions of highest level of educational attainment (**Table 1**) may have varied by COVID-19 vaccination intent ($P = 0.047$) and we observed higher frequencies of freshman, sophomores, and juniors indicating that they did not intend to get a COVID-19 immunization compared to seniors, graduates, and post-graduate students. We examined sensitivity of the mediation by education model by testing use of highest level of educational attainment, and witnessed no statistically significant mediation (data not shown).

While neither status as a current student, nor month in which the survey was taken, completely explained the association between rurality and vaccination intent, we observed trends over time in both mediators. As shown in **Fig. 1** (and **Table A.2**), we observed an increase in the percent of participants not intending to obtain a COVID-19 vaccination, and a diverging trend in vaccination intent, that grew over time, between rural and urban young adults from December 2020 to April 2021. Prior to December, vaccination intent had been increasing and converging between rural and urban young adults. Additionally, December 2020 saw the lowest proportion of current students among rural young adults (60.4%), and yet the highest proportion of rural young adults expressing (positive) intent to receive the COVID-19 vaccine (79.2%); whereas, March to April 2021 saw the highest proportion of rural young adults not to get a COVID-19 vaccine (55.6%, 54.7%), and approximately equal proportions of current students (versus not) among rural young adults (50.0%, 46.8%). Additionally, we examined interaction in our favored model of odds of intent to vaccinate, by testing the significance of the interaction terms. We did not find any to be statistically different, suggesting that there was no EMM of the hypothesized relationship, between rurality and COVID-19 vaccination intent, by age, gender, race and ethnicity, student status, or time of survey (data not shown).

3.3. Vaccination attitudes and COVID-19 impacts

In this study population, rural young adults were more vaccine hesitant and reported being less concerned and/or less affected by the COVID-19 pandemic. A significantly larger proportion of rural participants stated that they would be 'unlikely' to obtain a COVID-19 immunization compared with urban young adults, even if it was recommended by their health care provider (24.0% vs. 7.0%, $P < 0.001$), as shown in **Table 3**. Rural young adults also indicated, at significantly ($P < 0.001$) higher proportions compared with their urban counterparts, being 'not at all concerned' about COVID-19 (18.0% vs. 7.1%), that they were self-isolating 'none of the time' (18.0% vs. 6.9%), that they had 'not changed lifestyle or daily activities' (19.0% vs. 7.0%), and that their mental health status had not been affected by the pandemic (24.0% vs. 16.0%).

4. Discussion

This study endeavored to move beyond confirmatory analyses and address COVID-19 vaccine hesitancy among young adults in rural areas for health care professionals, policy makers, researchers and future interventions. We observed the hypothesized relationship between rurality and COVID-19 immunization intent was mediated by status as a current student (yes or no), but not by classification in college (e.g., freshman/first year, sophomore, etc.), and that the strength of association between being a current student and intending to vaccinate was stronger than classification in college, suggesting that it is currency of education, and not level of education that offers promise for future interventions.

We observed vaccination intent between urban and rural young adults converging from October to December 2020, reaching its highest level during the study period in December 2020 and then diverging from January to April 2021. The shift in trend we witnessed may be related, in part to the emergency use authorization, of the Pfizer-BioNTech COVID-

Table 2

Odds of intent to obtain a COVID-19 vaccination, among Young Adults (18–26 y/o) in the western U.S., Oct. 2020 – Apr. 20,21.¹

| | aOR (95% CI) ^{2,3} |
|---------------------------------------|-----------------------------|
| Age | |
| 18–19 | ref or 1.00 |
| 20–24 | 1.24 (1.01 to 1.51) |
| 25–26 | 1.35 (1.03 to 1.76) |
| Gender | |
| Female | — |
| Male | 1.20 (1.01 to 1.43) |
| Other | 1.17 (0.63 to 2.19) |
| Race and Ethnicity⁴ | |
| Not-Hispanic White/Caucasian | — |
| Not-Hispanic Minority | 1.37 (1.10 to 1.70) |
| Hispanic/Latino | 0.97 (0.79 to 1.21) |
| Student | |
| No | — |
| Yes | 1.29 (1.08 to 1.55) |
| Time of Survey | |
| October | — |
| November | 1.53 (1.04 to 2.29) |
| December | 1.57 (1.22 to 2.04) |
| January | 0.88 (0.62 to 1.25) |
| February | 0.76 (0.51 to 1.13) |
| March | 0.60 (0.45 to 0.78) |
| April | 0.72 (0.55 to 0.96) |
| Rurality | |
| Urban | — |
| Mixed | 0.69 (0.50 to 0.96) |
| Rural | 0.62 (0.50 to 0.76) |

¹ Odds of expressing intent to vaccinate compared with not intending to vaccinate or being unsure.

² Adjusted for age, gender, race and ethnicity, education (self-identifying as a current student), and month of survey.

³ OR = Odds Ratio, CI = Confidence Interval.

⁴ Missing n = 48 responses.



Fig. 1. COVID-19 vaccination intent and status as a current student, over time and by geographic area, among young adults (ages 18–26 years) in the western U.S., October 2020–April.

19 vaccine for individuals 16 years and older, by the U.S. Food and Drug administration (December 11, 2020), representing a shift from the theoretical question of willingness to vaccinate, to a practical reality. The finding of lower vaccine acceptance in rural areas has also been documented in other studies (Khubchandani et al., 2021; Kricorian et al., 2022; McElfish et al., 2021); as has higher acceptance of the COVID-19 vaccine among students (Sallam, 2021) and/or those with higher education attainment (Khubchandani et al., 2021; Kricorian et al., 2022; McElfish et al., 2021). Observing the change in vaccine acceptance over time is not well documented but has been noted and described elsewhere (Sallam, 2021). One longitudinal study in the Netherlands found COVID-19 vaccine acceptance increased in the six months following widespread vaccine release (Boekel et al., 2022). Although it is unclear exactly what lies behind the shift in vaccination trends, our results suggest that student status effects on vaccination decisions, differ between urban and rural young adults, which may be attributable to differences in access and sources of information (Puri et al., 2020; Charron et al., 2020; Dunn et al., 2017; Ortiz et al., 2019); and may offer modifiable and important areas for future interventions.

4.1. Limitations

While our results suggest differences in access and sources of information, between rural and urban young adults, we may have excluded those without and/or lower access to internet, which may have biased results. While 12 western U.S. states were represented in this study population, 38% of participants were from Utah (data not shown). In Utah approximately 15% of households do not have access to internet (cost and/or availability prohibitive) and 13% do not have a computer (Council, 2020). Similarly, observed differences, in the association of rurality and vaccination intent, was limited in that we did not ask direct questions about sources of health information, internet access, or social media use, and further research is warranted.

Furthermore, ‘rural’ classifications were defined using the U.S. Department of Agriculture’s RUCC ≥ 4 . County of residence was unavailable and participant zip codes were associated with county-level RUCCs, which resulted in the geographic classification of ‘mixed’ for zip codes that contained both RUCC < 4 and RUCC ≥ 4 . These areas are spatially heterogenous, and we witnessed that they, like rural areas,

differed from the urban areas. Namely, young adults in areas classified as ‘mixed’ had 31% less odds of intending to receive a COVID-19 vaccination compared with urban young adults (adjusted odds ratio, 0.69 [95% CI, 0.50–0.96]). RUCCs are spatially coarse, may miss important finer-scale details, and/or misclassify exposures. Additionally, zip codes (created for postal delivery convenience) may not align with demographic characteristics and may suffer from classification bias due to modifiable areal unit problems. Nonetheless, use of RUCCs is well established and offers important comparability across studies. A notable strength was a large number of participants, which allowed analysis of zip codes that contained both rural and urban classifications to be included separately, instead of excluding from analysis, or classifying based on areal interpolation (Wilson and Din, 2018).

This study sought to examine the association of vaccine hesitancy and rurality but was limited in a few key areas. Longitudinal examination of uptake of COVID-19 immunization may have been preferable to utilizing self-reported intent to vaccinate; however, our cross-sectional study began prior to vaccine availability and examination by uptake was not possible. Utilizing vaccination intent offered a reasonable proxy for vaccine hesitancy and allowed for examination of population-level time-varying changes in vaccination sentiment. This study may have been biased away from the null hypothesis due to social-desirability bias, whereby participants may have given answers perceived to be more desirable by their local communities, which may have differed by rurality. Additionally, widespread fraudulent responses were detected and 41.6% of collected responses met quality control standards. It is possible that some responses included were fraudulent, or that quality control methods, may have biased results; however, expected bias would be nondifferential.

While we performed causal mediation analysis, the analysis rests on the assumption that all confounders of the rurality-vaccination intent relationship were accurately depicted in the DAG, that all depicted relationships were correctly ordered, and no reciprocal causation between vaccination intent and month of survey, nor education. Thus, we are unable to identify a causal relationship between rurality and COVID-19 immunization intent. The study population was young, had some college education, and access to the internet, thus results may not be generalizable. Notable strengths included a large geographic area and good representation of Hispanic individuals (17%) and rural residents (39%).

5. Conclusions

COVID-19 vaccine hesitancy is greater among rural young adults, and grew disproportionately after December 2020, compared with urban young adults. Mediation, by whether one was a current student or not, suggests differences in currency and sources of health and vaccine information among young adults, offering promise for clinical practice and future interventions addressing vaccine hesitancy.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Disclaimer

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.pmedr.2022.101845>.

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