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Sociocultural Antecedents and Mechanisms of COVID-19 Vaccine Uptake among Mexican-Origin Youth

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ABSTRACT

Mexican-origin youth, as a large and growing population among U.S. youth, have been disproportionately affected by COVID-19. Understanding what, when, and how sociocultural factors may influence their COVID-19 vaccine uptake could inform current and future pandemic-response interventions promoting vaccination behaviors among Mexican-origin youth. The current study takes a developmental approach to reveal the long-term and short-term sociocultural antecedents of 198 Mexican-origin adolescents' COVID-19 vaccination uptake behaviors and explores the underlying mechanism of these associations based on the Knowledge-Attitude-Behavior model. The current study adopted Wave 1 (2012–2015) and Wave 4 (2021–2022) self-reported data from a larger study. Analyses were conducted to examine four mediation models for four sociocultural antecedents—daily discrimination, ethnic discrimination, foreigner stress, and family economic stress—separately. Consistent indirect effects of higher levels of concurrent sociocultural risk factors on a lower probability of COVID-19 vaccine uptake were observed to occur through less knowledge about the COVID-19 vaccines and less positive attitudes toward the COVID-19 vaccines at Wave 4. Significant direct effects, but in opposite directions, were found for the associations between Wave 1 ethnic discrimination/Wave 4 daily discrimination and the probability of COVID-19 vaccine uptake. The findings highlight the importance of considering prior and concurrent sociocultural antecedents and the Knowledge-Attitude-Behavior pathway leading to COVID-19 vaccination uptake among Mexican-origin youth and suggest that the impact of discrimination on COVID-19 vaccination uptake may depend on the type (e.g., daily or ethnic) and the context (e.g., during the COVID-19 pandemic or not) of discrimination experienced.

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Introduction

COVID-19, the illness caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), represents an unprecedented threat to public health around the world. Successful uptake of COVID-19 vaccines within the U.S. is perhaps the most important strategy for curbing and ultimately stopping the ongoing pandemic,[1] especially among ethnic minority communities that have been disproportionately affected by COVID-19. Latino populations have experienced higher rates of COVID-19 infection and death. Specifically, Latinos are 1.5 times more likely to be infected with COVID-19 and 1.8 times more likely to die from COVID-19 compared to non-Hispanic Whites.[2] Simultaneously, despite the increased burden of COVID-19 among Latinos, their COVID-19 vaccination rates have lagged behind those of Whites.[3] Mexican-origin individuals comprise the largest Latino ethnic group in the U.S.,[4] and they are also characterized as being one of the most youthful and fastest-growing populations in the U.S.,[5] which positions Mexican-origin adolescents and young adults as a large contingent of a subgroup particularly vulnerable to COVID-19. Therefore, the current study seeks to discern the sociocultural factors associated with their COVID-19 vaccination status, both concurrently and longitudinally. The findings can aid current and future pandemic-response efforts about how to target

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and time intervention points, focusing on relevant sociocultural stressors at key stages of adolescence, to promote vaccination behaviors among Mexican-origin young adults.

While adolescents and young adults' vaccination behaviors have been primarily studied within the context of parent-child communication,[6] sociocultural stressors confronted by Latino families (which include disproportionate economic disadvantages and cultural barriers) set the stage for Mexican-origin adolescents' COVID-19 vaccine uptake over the course of their development. Further, given that our study participants were primarily 18 years or older at the time of their COVID-19 vaccination, parental consent was not necessary to receive it, and parent-child communication may have been less salient than other sociocultural factors. Youth are more autonomous at this developmental stage and studies have yet to assess how Mexican-origin adolescents' sociocultural environment directly influences their COVID-19 vaccine uptake—as specific stressors can marginalize them within healthcare settings and/or preclude the receipt of needed health information. More specifically, Latinos confront inequities in income status, which have been linked to greater perceived barriers to receiving the COVID-19 vaccine due to false perceptions of the inability to pay.[7] Additionally, past experiences of racial discrimination contribute to greater COVID-19 vaccination hesitancy among ethnic minorities.[8] Latinos are exposed to various discrimination experiences that are tied to their ethnic membership (i.e., ethnic discrimination)[9] and assumptions that they are foreign-born (i.e., foreigner stress),[10] which research has yet to consider independently in relation to COVID-19 vaccination even though studies have documented that Latinos experience ethnic discrimination and foreigner stress within healthcare settings specifically.[11,12] In turn, discrimination experiences in healthcare systems contribute to a greater mistrust of medical professionals and skepticism about the COVID-19 vaccine among Latinos.[13] Lack of information and resources in Spanish regarding the COVID-19 vaccines may have also posed significant challenges to many Latinos.[7] Thus, these sociocultural factors are critical to consider in understanding Mexican-origin adolescents' COVID-19 vaccine uptake, especially considering that the study sample draws from immigrant households, who may be experiencing more pervasive foreigner stress due to their families' immigrant status in addition to sociocultural stress related to their ethnic membership.[14]

Aspects of Mexican-origin families' sociocultural environment can also shape adolescents' cognitive processes surrounding the COVID-19 vaccination, specifically their knowledge about the COVID-19 vaccine. False perceptions of the inability to afford the COVID-19 vaccine may preclude pursuing further information regarding its efficacy. Marginalization within healthcare systems due to discrimination and a mistrust of medical professionals can also distance Mexican-origin youth from key sources of information regarding the COVID-19 vaccine. Lastly, less availability of COVID-19 vaccine information in Spanish can also pose a significant limitation for a proportion of Mexican-origin youth due to language barriers. This is concerning, given that knowledge of health behaviors, as delineated by the Knowledge-Attitude-Behavior (KAB) model,[15] spurs a key cognitive pathway *via* attitudes, leading ultimately to the enactment of health behaviors like COVID-19 vaccination. More specifically, the model posits that the acquisition of knowledge about a specific health behavior (i.e., learning about the COVID-19 vaccine) influences favorable attitudes toward the behavior (i.e., endorsing the efficacy of the COVID-19 vaccine), which in turn shapes behavior formation (i.e., deciding to receive the COVID-19 vaccine). For Mexican-origin adolescents, the process that moves them from acquiring knowledge about the COVID-19 vaccine to receiving the COVID-19 vaccine is situated within their sociocultural environment. Thus, it is important to consider how social and cultural factors directly and indirectly influence COVID-19 vaccine uptake, *via* COVID-19 knowledge and attitudes.

Studies taking a developmental approach can also reveal the long-term and short-term antecedents of Mexican-origin adolescents' COVID-19 vaccination behaviors and contribute to an understanding of how key sociocultural factors, at different phases of adolescence, influence COVID-19 vaccine uptake. Longitudinal studies are important to discern how aspects of the sociocultural ecologies of Mexican-origin youth not only affect their immediate vaccination behaviors (i.e., concurrent effect) but can also have far-reaching consequences on their vaccination status from early to late adolescence (i.e., longitudinal effect). Research has shown that prior sociocultural stress exposure (e.g., discrimination) relates to increased COVID-19 vaccine hesitancy among ethnic minorities,[8] but studies have yet to assess the salience of the *timing* of sociocultural stress exposure (i.e., in early or late adolescence) in relation to COVID-19 vaccination. Theories regarding the impacts of stress over the life course posit that past experiences of stress, like socioeconomic disadvantage and discrimination, have a prospective impact on individuals by eliciting

a severely negative response at the time of encountering a stressor, heightening their anticipation of the next event.[16] Therefore, sociocultural stress exposure during early adolescence may condition negative outcomes (e.g., marginalization within healthcare systems) that influence cognitive processes underlying vaccination behaviors and/or eventual COVID-19 vaccine uptake among Mexican-origin youth long after the original exposure. The current study is uniquely positioned to examine how dimensions of Mexican-origin adolescents' sociocultural stress, assessed at different phases of adolescence and encompassing times pre- and post-onset of the COVID-19 pandemic, directly and indirectly informed their COVID-19 vaccine uptake.

The current study examines how salient sociocultural factors (i.e., daily discrimination, ethnic discrimination, foreigner stress, and economic stress) affect COVID-19 vaccination both directly and indirectly *via* the Knowledge-Attitude-Behavior process within a Mexican-origin adolescent and young adult sample. This is an important research gap to address given the sizable growth of the Latino population in this age group, disparities in COVID-19 vaccination status among Latinos, and the higher risk of COVID-19 disease and death among Latinos. As shown in Figure 1, the aims of the current study are to (1) test the cross-sectional and longitudinal direct effects of daily discrimination, ethnic discrimination, foreigner stress, and economic stress on Mexican-origin adolescents' COVID-19 vaccination status (A1); and (2) test the cross-sectional and longitudinal indirect effects of daily discrimination, ethnic discrimination, foreigner stress, and economic stress on Mexican-origin adolescents' COVID-19 vaccination status *via* COVID-19 vaccine knowledge → positive COVID-19 vaccine attitudes → COVID-19 vaccination behaviors (B1 to B2 to B3).

Methods

Participants

The current study utilized Wave 1 and Wave 4 data from a four-wave longitudinal study (Wave 1: 2012–2015; Wave 4: August 2021–December 2022). Participants were from low-income families in central Texas, with the median household income between $20,001 to $30,000 and the average highest education level of participants' parents being middle/junior high school at Wave 1. Only data from the 198 Mexican-origin adolescents still participating in Wave 4 were used, as the current study focused on COVID-19-related variables, which were collected only at Wave 4. Adolescent ages ranged from 11 to 15 ($M_{age} = 12.39$, $SD = .92$) at Wave 1 and 17 to 23 years old ($M_{age} = 20.41$, $SD = 1.26$) at Wave 4. Females make up more than half the sample ($N_{female} = 123$, 61.5%), and ~76% of participants were born in the U.S. Attrition analysis showed no significant difference in Wave 1 demographic information or sociocultural stress variables between those who participated in

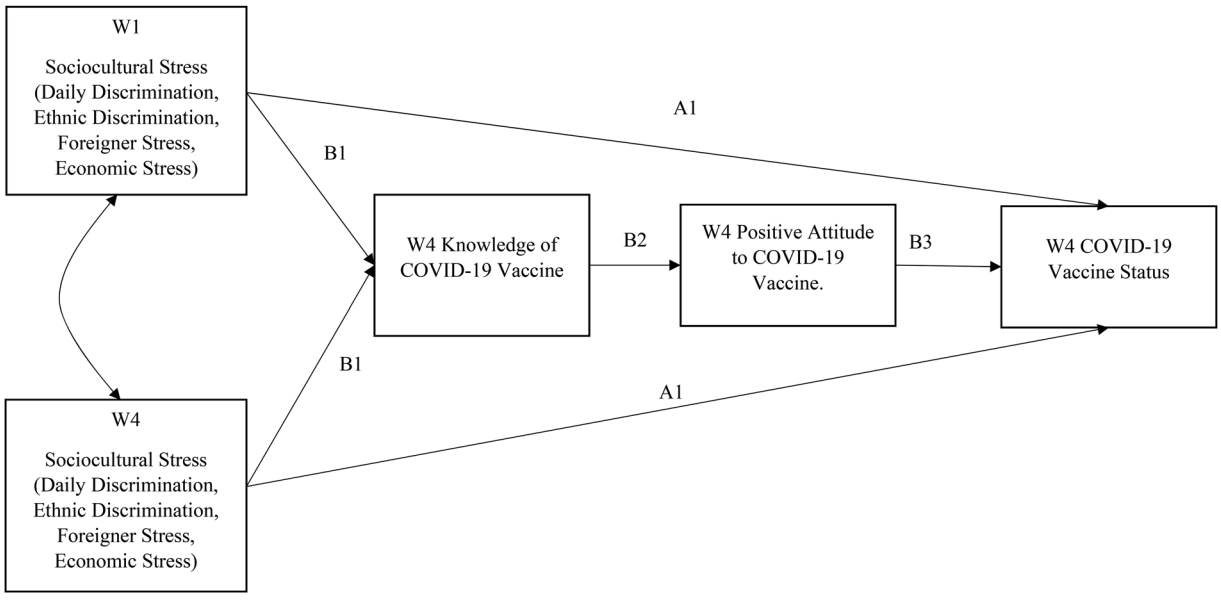

Figure 1. Conceptual model of indirect effect from sociocultural stress to COVID-19 vaccine status. *Note.* Each sociocultural stressor (i.e., daily discrimination, ethnic discrimination, foreigner stress, and economic stress) was analyzed separately in four separate models. W1: Wave 1; W4: Wave 4.

Wave 4 and those who did not, with the exception of gender [X^2 (1, $N = 604$) = 7.24, $p = .009$]. Females were more likely to participate in Wave 4 than males, so gender was controlled in data analysis.

Procedure

Participants were initially recruited through school presentations, community recruitment, and public records. Families were selected if parents were of Mexican origin and their target child translated between English and Spanish for at least one of the parents (mother or father). Informed consent from parents and informed assent from adolescents were obtained. In the interview process, bilingual and bicultural interviewers read questionnaires to parents and adolescents. Questionnaires were presented in both English and Spanish so that participants could choose the language with which they were more comfortable. Participants' responses were recorded on a laptop computer. Research assistants reached out to all families who had participated in the previous wave (i.e., Wave 3) and invited families that could be contacted to participate in Wave 4 data collection. Participating families were compensated $60 at Wave 1 and $70 at Wave 4. All procedures received Institutional Review Board approval from the corresponding author's university.

Measures

Sociocultural stress

Sociocultural stress variables include adolescents' self-reported daily discrimination, ethnic discrimination, foreigner stress, and family economic stress in Waves 1 and 4. Longitudinal measurement invariance testing was conducted for each stress variable, following established procedures,[17] and the results are presented in Table S2. All measures met the criteria for longitudinal metric invariance to make meaningful comparisons of associations between variables.

Daily discrimination. Adolescents' perception of daily discrimination at Wave 1 and Wave 4 was assessed using a nine-item scale, the Everyday Discrimination Scale, ranging from 1 (never) to 4 (often).[18] Sample items included, "I am treated with less respect than other people." Higher mean scores represent greater perceived discrimination ($\alpha_{\text{wave 1}} = .82$, $\alpha_{\text{wave 4}} = .87$). The original developers demonstrated construct validity by showing that daily discrimination was negatively associated with adults' well-being ($b = -0.550$, $p < .01$), and positively associated with adults' self-rated ill health ($b = .108$, $p < .05$), physical in-capacitation (the number of days adults can't work or carry out normal activities due to physical and mental illnesses) ($b = .118$, $p < .01$), and psychological distress ($b = 2.818$, $p < .01$) in racially diverse samples. Previous research using this measure also demonstrated construct validity by showing a significant association between everyday discrimination and health behaviors, such as sleep, among Latino samples ($b = .16$, $p < .001$).[19]

Ethnic discrimination. Adolescents' perception of ethnic discrimination at Wave 1 and Wave 4 was assessed by a nine-item scale adapted from the Everyday Discrimination Scale,[18] ranging from 1 (never) to 4 (often). The phrase "because I am Mexican" was added to the end of each item to measure adolescents' discriminatory experiences related to their ethnic minority status. Sample items included, "I am treated with less respect than other people because I am Mexican." Higher mean scores indicate more discrimination that adolescents experienced because of their Mexican heritage ($\alpha_{\text{wave 1}} = .88$, $\alpha_{\text{wave 4}} = .91$). Previous research using this measure demonstrated construct validity by showing a significant association between this measure of ethnic discrimination and the adolescent outcome of self-esteem among Latino samples ($B = -0.13$, $p < .05$).[20]

Foreigner stress. Adolescents' perceived foreigner stress at Wave 1 and Wave 4 was assessed using a four-item scale,[21] ranging from 1 (strongly disagree) to 5 (strongly agree). Sample items included, "Because of how I speak, people sometimes assume I am not a U.S. American." Higher mean scores represent more experiences of being perceived as a foreigner ($\alpha_{\text{wave 1}} = .70$, $\alpha_{\text{wave 4}} = .76$). The developers of this measure demonstrated construct validity by showing that foreigner stress was associated with Mexican-origin adolescents' delinquency ($b = .03$, $p < .01$).[22] Previous research using this measure also demonstrated construct validity by showing the association between foreigner stress and depressive symptoms in an ethnic minority sample ($b = .19$, $p = .03$).[23]

Family economic stress. Adolescents' perception of family economic stress at Wave 1 and Wave 4 was measured using a five-item scale, ranging from 1 (never) to 5 (always).[24] Sample items included, "Did your parents argue with each other about not having enough money," and "Did you and your parents disagree or get upset about money?" Higher mean

scores show a greater frequency of experiencing family economic stress ($\alpha_{\text{wave 1}} = .73$, $\alpha_{\text{wave 4}} = .86$). The original developers of this measure demonstrated construct validity by showing that adolescents' perceived family economic stress was positively associated with adolescent depressive symptoms in a Chinese American sample ($b_{wave\ 1} = .16$, $p_{wave\ 1} < .05$; $b_{wave\ 2} = .36$, $p_{wave\ 2} < .01$). The latent variable of family economic stress was comprised of three subscales in the original paper: family financial difficulty, parents' financial worries, and families' conflict over money; all three subscales' factor loadings were statistically significant. Previous research using this measure demonstrated construct validity by showing a significant association between family economic stress and the adolescent outcome of academic achievement in a racially diverse sample ($B = -0.41$, $p = .034$).[25]

COVID-19 vaccine-related variables

COVID-19 vaccine knowledge. Adolescents' COVID-19 vaccine knowledge at Wave 4 was assessed using a three-item scale adapted from a previous study, ranging from 1 (strongly disagree) to 5 (strongly agree).[26] Items included, "I am confident in my ability to find information about the COVID-19 vaccine," "Information about the COVID-19 vaccine is easy to access," and "I have a hard time finding information in Spanish on how to get the COVID-19 vaccine" (reverse coded). Higher mean scores indicate more knowledge about the COVID-19 vaccine ($\alpha_{\text{wave 4}} = .66$). Construct validity is demonstrated in the current study as COVID-19 vaccine knowledge is negatively related to Wave 4 adolescent daily discrimination ($B = -0.221$, $p = .004$), Wave 4 foreigner stress ($B = -0.309$, $p = .001$) and Wave 4 family economic stress ($B = -0.251$, $p = .002$), as expected.

COVID-19 vaccine positive attitude. Adolescents' positive attitude toward the COVID-19 vaccine at Wave 4 was assessed using a three-item scale adapted from a previous study, ranging from 1 (strongly disagree) to 5 (strongly agree).[27] Items included, "The COVID-19 vaccine can be trusted," "It is beneficial to take the COVID-19 vaccine," and "The COVID-19 vaccine is safe." Higher mean scores represent more positive attitudes toward the COVID-19 vaccine ($\alpha_{\text{wave 4}} = .91$). The original developers demonstrated construct validity by showing that COVID-19 vaccine positive attitude was positively associated with COVID-19 vaccine knowledge ($b = .452$, $p < .001$) and negatively associated with vaccine hesitancy ($b = -0.338$, $p < .001$).[27]

COVID-19 vaccine status. Adolescent COVID-19 vaccine status at Wave 4 was measured by asking, "Have you received the COVID-19 vaccine?" Answer choices included "yes" and "no."

Covariates

A set of demographic variables, including adolescents' age and gender, was included as covariates. The age of participants may impact vaccine hesitancy.[28] Maternal education was also included because previous studies have indicated that it may impact adolescent vaccine uptake.[29,30] Mothers self-reported their education level on a scale of 1 (no formal schooling) to 11 (finished graduate degree). Previous literature has illustrated that individuals are more likely to receive COVID-19 vaccines when COVID-19 vaccines have been available for a longer period of time;[31] thus, the time when youth reported their COVID-19 vaccine uptake status was controlled in the current study. Specifically, the timing was controlled by calculating the time that had elapsed since the start of Wave 4 (i.e., each participant's interview date minus the date when Wave 4 started).

Analysis

Data was analyzed using Mplus 8.3 with the weighted least squares mean and variance adjusted estimator (WLSMV) given that the outcome is a categorical variable.[32] Four probit regression models were analyzed to examine the separate impacts of sociocultural stress (i.e., daily discrimination, ethnic discrimination, and foreigner stress) and family economic stress on adolescent vaccine status (see Figure 1). The direct effects of Wave 1 and Wave 4 sociocultural stress and family economic stress on Wave 4 adolescent vaccine status were estimated. The indirect effects of Wave 1 and Wave 4 sociocultural stress and family economic stress on Wave 4 adolescent vaccine status through Wave 4 COVID-19 vaccine knowledge to Wave 4 adolescent vaccine positive attitude were estimated. A 95% confidence interval (CI) was examined to determine the significance of the indirect effect estimates. Models were considered acceptable when they satisfied the following criteria: the Comparative Fit Index (CFI) approaches or exceeds 0.95, the Root Mean Square Error of Approximation (RMSEA) approaches or falls below 0.06, and the Standardized Root Mean Square Residual (SRMR) approaches or falls below 0.08.[33] The mediation was modeled with a Bootstrap of 5,000 to provide robust estimates with 95% confidence intervals.[34]

Results

Table 1 displays the descriptive statistics of demographic and study variables for the sample. Correlations of studied variables are presented in Table S1. Table 2 provides the standardized direct and indirect effects of Wave 1 and Wave 4 sociocultural factors (i.e., daily discrimination, ethnic discrimination, foreigner stress, and economic stress) on Wave 4 vaccine status. All four mediation models with probit regressions demonstrate acceptable model fits (i.e., CFI ranges from .958 to .973; Standardized Root Mean Square Residual ranges from .043 to .049; Root Mean Square Error of Approximation ranges from .038 to .050).

In terms of the concurrent link between sociocultural factors and vaccine uptake, the most consistent significant findings emerged in the indirect associations. Specifically, after controlling for the influence of Wave 1 sociocultural stress experiences on COVID-19 vaccine uptake, experiencing higher levels of daily discrimination (Model 1), foreigner stress (Model 3), or economic stress (Model 4) at Wave 4 related to less knowledge about the COVID-19 vaccine, which was related to lower positive attitude towards the COVID-19 vaccine, which was ultimately related to a lower probability of COVID-19 vaccine uptake. In terms of direct associations for the concurrent link, there was a significant and unexpected direct association from daily discriminatory experiences to COVID-19 vaccine uptake (Model 1). Specifically, youth who experienced higher levels of daily discrimination at Wave 4 had a higher probability of COVID-19 vaccine uptake, taking into account the indirect association between Wave 4 daily discrimination and COVID-19 uptake probability. In terms of the longitudinal link between sociocultural factors and vaccine uptake, there was a direct association between ethnic discrimination and COVID vaccine uptake (Model 2). Youth who experienced more ethnic discrimination at Wave 1 were less likely to receive a COVID-19 vaccine during the pandemic.

Table 1. Descriptive table of demographic information and study variables.

	M(*SD*) or % (n)
Gender	
Boy	37.9% (75)
Girl	62.1% (123)
Nativity	
U.S	76.3% (151)
Mexico	23.7% (47)
W4 adolescent age	20.42 (1.26)
Maternal education	
1 No formal schooling	3.5% (7)
2 Some elementary school	9.6% (19)
3 Finished elementary school	15.7% (31)
4 Some middle school/junior high school	12.6% (25)
5 Finished middle school/junior high school	20.2% (40)
6 Some high school	13.1% (26)
7 Finished high school	11.1% (22)
8 Finished technical or vocational training after high school	8.1% (16)
9 Finished community college degree (AA)	0.5% (1)
10 Finished university/bachelor's degree (BA/BS)	5.6% (11)
Time	0.54 (0.35)
W1 daily discrimination	1.65 (0.49)
W1 ethnic discrimination	1.39 (0.48)
W1 foreigner stress	2.46 (0.79)
W1 economic stress	1.93 (0.70)
W4 daily discrimination	1.48 (0.47)
W4 ethnic discrimination	1.43 (0.48)
W4 foreigner stress	2.38 (0.74)
W4 economic stress	1.68 (0.72)
W4 knowledge of Covid-19 Vaccine	3.82 (0.68)
W4 positive attitude to COVID-19 vaccine	3.45 (0.88)
W4 Covid-19 vaccine status	
Vaccinated	70.2% (139)
Not vaccinated	29.8% (59)

Note. $N = 198$; W = Wave; Time: timing of COVID -19 vaccine uptake calculated by using each participant's interview date minus the date when Wave 4 started (years).

Discussion

Utilizing a developmental approach, the current study uncovers both the long-term and short-term links from sociocultural factors before and during the COVID-19 pandemic on Mexican-origin adolescents' vaccination behaviors. Mexican-origin adolescents who reported more ethnic discrimination experiences in early adolescence were less likely to be vaccinated for COVID-19 in late adolescence, revealing that early stress exposure to ethnic discrimination may have far-reaching impacts on future health behavior formation. Multiple concurrent stressors in Mexican-origin adolescents' sociocultural environment, including daily discrimination, foreigner stress, and economic stress, were indirectly associated with Mexican-origin adolescents' lower probability of COVID-19 vaccine uptake. Concurrently, Mexican-origin adolescents with higher levels of daily discrimination, foreigner stress, and economic stress reported less knowledge about the COVID-19 vaccine, which was in turn associated with less positive attitudes toward COVID-19 vaccination, which ultimately linked to a lower probability of COVID-19 vaccine uptake. By assessing different developmental periods of adolescence, the current study suggests that concurrent sociocultural stressors may be more critical than early sociocultural stressors in informing Mexican-origin adolescents' vaccination status. These findings add to the growing body of research on COVID-19 vaccinations by highlighting the influence of prior and concurrent sociocultural stressors on the Knowledge-Attitude-Behavior (KAB) pathway leading to COVID-19 vaccination behaviors among Latino adolescents and young adults, a large

Table 2. Direct and indirect effects from sociocultural stress to vaccine status (standardized).

Model	Mediational Pathway	Estimated Effect	95% Confidence Interval
1	***W1*** *Discrimination* → ***W4*** *Vaccine Status*		
	Directly	−.16	[−.34, .02]
	via Knowledge of vaccine → Positive attitude to vaccine	−.02	[−.06, .03]
	W4 *Discrimination* → ***W4*** *Vaccine Status*		
	Directly	.17*	[.01, .33]
	via Knowledge of vaccine → Positive attitude to vaccine	−.06*	[−.10, −.01]
2	***W1*** *Ethnic Discrimination* → ***W4*** *Vaccine Status*		
	Directly	−.20*	[−.36, −.03]
	via Knowledge of vaccine → Positive attitude to vaccine	.01	[−.03, .05]
	W4 *Ethnic Discrimination* → ***W4*** *Vaccine Status*		
	Directly	.09	[−.10, .27]
	via Knowledge of vaccine → Positive attitude to vaccine	−.02	[−.06, .01]
3	***W1*** *Foreigner Stress* → ***W4*** *Vaccine Status*		
	Directly	−.17	[−.35, .01]
	via Knowledge of vaccine → Positive attitude to vaccine	.02	[−.02, .07]
	W4 *Foreigner Stress* → ***W4*** *Vaccine Status*		
	Directly	.08	[−.10, .25]
	via Knowledge of vaccine → Positive attitude to vaccine	−.08*	[−.14, −.01]
4	***W1*** *Economic Stress* → ***W4*** *Vaccine Status*		
	Directly	−.12	[−.28, .03]
	via Knowledge of vaccine → Positive attitude to vaccine	.00	[−.04, .05]
	W4 *Economic Stress* → ***W4*** *Vaccine Status*		
	Directly	.00	[−.18, .18]
	via Knowledge of vaccine → Positive attitude to vaccine	−.06*	[−.10, −.01]

Note. $N = 198$; W = Wave; vaccine = COVID-19 vaccine.

ethnic group that is especially vulnerable to COVID-19.[5] The results of this study may have the potential to guide future efforts aimed at increasing vaccination rates among this population in preparation for future outbreaks.

Among the various sociocultural factors being examined, ethnic discrimination was the only stressor in early adolescence with a direct impact in late adolescence: Mexican-origin adolescents who were exposed to more instances of ethnic discrimination at Wave 1 had a lower probability of receiving the COVID-19 vaccine at Wave 4 during the pandemic. This is consistent with prior research, which suggests that ethnic discrimination could play a key role during adolescence, a time when individuals undergo significant changes in cognitive appraisal processes that could have long-lasting effects.[35,36] The study finding also aligns with broader research on health disparities among Latinos, which highlights the negative health impact of perceived discrimination related to ethnicity in childhood or early adolescence.[37] Considering the developmental perspective on Latino health care disparities, this study empirically demonstrates the salience of the timing of sociocultural stress exposure in terms of its influence on adolescents' health behaviors. Prior research has suggested that prolonged, stressful sociocultural experiences could threaten one's perception of self, which could elicit adverse behavioral changes related to health.[38] For instance, Mexican-origin adolescents may perceive their experiences of ethnic discrimination in early adolescence as signals of rejection from the society and develop negative self-evaluations, which may lower their desire to be vaccinated in late adolescence.

Prior research also suggests that ethnic discrimination, a persistent form of racism, may be linked to Latinos' mistrust of the U.S. medical system, given that its discriminatory practices against Latino communities may be a barrier to receiving quality health care.[13,39] These discriminatory experiences can accumulate over the course of life and across generations,[40] influencing Latinos' health behaviors, such as getting vaccinated during the COVID-19 pandemic. Early adolescence is a critical period when parents are the primary source of information and support for Latino adolescents navigating experiences of discrimination.[41] A previous qualitative study found that Latino adolescents echoed their parents' mistrust of vaccination, which may discourage their vaccine uptake.[42] However, this study did not examine any data on parents' discriminatory experiences and how they may influence Mexican-origin adolescents' COVID-19 vaccine uptake, making it a possible direction for future research.

Among the current sample of Mexican-origin adolescents, concurrent sociocultural factors were associated with COVID-19 vaccine uptake directly or indirectly. Study findings showed that encountering higher levels of daily discrimination and foreigner stress were indirectly related to a lower probability of being vaccinated for COVID-19 through the KAB pathway. This underscores the salience of examining sociocultural stressors as precursors to cognitive

processes (i.e., knowledge and attitudes in the KAB pathway) that may shape health behaviors among younger Latino populations. Such an extension of the current KAB model may be necessary for understanding health behavior formation among ethnic minority youth. The Wave 4 data collection of this study occurred during August 2021 and December 2022, during the COVID-19 pandemic and also during the public charge rule against foreign-born populations.[43] The COVID-19 pandemic further exacerbated prejudice and discrimination against Latinos,[44] the largest immigrant population in the U.S., accounting for over 25% of all immigrants.[45] Considering Mexican-origin adolescents' sociocultural environment during the COVID-19 pandemic, it is possible that Mexican-origin adolescents may face ongoing stressors related to daily discrimination and being perceived as foreigners, which could potentially discourage them from being proactive about interacting with the health care system—for instance, seeking clarity on the conflicting, overwhelming, and culturally incongruent information about vaccines.[46,47] From the KAB model perspective, without clear and reliable knowledge about COVID-19 vaccines, Mexican-origin adolescents may be less likely to have positive attitudes about getting vaccinated, which may lead to lower rates of vaccine uptake.

However, the present study did uncover conflicting findings on the direct associations between cultural stressors and Mexican-origin adolescents' COVID-19 vaccine uptake. Ethnic discrimination at Wave 1 was associated with a reduced probability of COVID-19 vaccination.

Simultaneously, there was an unanticipated positive association between daily discrimination at W4 and COVID-19 vaccine uptake, suggesting that Mexican-origin adolescents who reported higher levels of concurrent daily discrimination were more likely to be vaccinated against COVID-19. However, given the lack of longitudinal measurement invariance noted for daily discrimination, the positive effect may need to be interpreted cautiously. Further, the association between W4 daily discrimination and COVID-19 vaccine uptake was insignificant at the bivariate level; only after accounting for the KAB pathway did this association become significant. One possible explanation for this unexpected direct effect may relate to a debatable idea in public health research, namely that stigmatization and discrimination could motivate individuals to adopt healthier behaviors.[48] For instance, the political climate against Latinos during the COVID-19 pandemic could have motivated Mexican-origin adolescents to get vaccinated as a way to combat societal blame and avoid being unfairly associated with virus contamination.[49] In other words, the social context of the COVID-19 pandemic could play a moderating role, where daily discrimination strengthened the unexpected positive association by exhibiting a positive effect on COVID-19 uptake rather than acting as a deterrent. Thus, the climate of the COVID-19 pandemic could make the influence of daily discrimination complex, and further investigation is needed to determine ways in which daily stress and recurrent experiences of discrimination may impact Mexican-origin adolescents' health behaviors, such as vaccine uptake. This may provide insight into current and future efforts aimed at enhancing booster uptake.

In addition, Mexican-origin adolescents with greater economic stress also had lower COVID-19 vaccination rates through less knowledge and less positive attitudes about the COVID-19 vaccine. The finding that those with greater economic stress had lower vaccination rates for COVID-19 is consistent with previous research on COVID-19 vaccination status among lower-income individuals, including Latinos.[13] Prior studies suggest that individuals with greater economic strain may not have access to health insurance.[50,51] This could mean that these individuals do not have primary care providers or other health professionals available to serve as authentic and trustworthy sources of information, who can debunk misinformation about COVID-19 vaccines.[52] This may contribute to Mexican-origin adolescents' less favorable attitudes toward vaccines, potentially resulting in a lower probability of receiving them.

The current study adds to the extant research on COVID-19 by demonstrating the long-term and short-term links of sociocultural stressors on Mexican-origin adolescents' vaccination behaviors. Study findings indicate a sequential effect from sociocultural factors to cognitive processes to health behavior formation, highlighting the need to extend the current KAB model by examining culturally situated precursors for a better understanding of health behaviors among ethnic minorities, including Latinos. Study findings suggest that the KAB model may be useful in disentangling the ways in which prior and concurrent sociocultural factors influence Mexican-origin adolescents' vaccine uptake within a shorter time period. Using a longitudinal approach, study findings also demonstrate that experiences during early adolescence can have a profound impact on young adulthood. The unique study design, encompassing early and late adolescence, adds to the health disparity literature on COVID-19 vaccine uptake by showing that the timing of sociocultural stress exposure could

be so critical that it has far-reaching effects on Mexican-origin adolescents' future health behavior formation. As such, prevention and intervention efforts that target key developmental periods of adolescence must be considered in (re)shaping Latino adolescents' health behaviors.

While the study findings make several important advancements in extant research regarding COVID-19 vaccination behaviors among racial/ethnic minority communities, there are specific limitations worth noting. One limitation of the current study is that the 9-year time gap between Wave 1 and 4 may mask possible indirect KAB pathways that lead to Mexican-origin adolescents' vaccine uptake. Another limitation is that findings on the short-term effect are cross-sectional. It would also be ideal for the COVID-19 related variables to be temporally spaced apart rather than being collected at the same time as all Wave 4 variables. Indeed, these results do not allow us to determine causality or track changes in Mexican-origin adolescents' vaccine uptake across time, especially if there have been multiple doses of COVID-19 vaccines. Future research may utilize survival analysis—for example, the Cox proportional hazards model—to identify how sociocultural stressors may influence vaccination behaviors among Mexican-origin adolescents at different time periods. Moreover, it is possible that the sociocultural stressors may amplify each other's effects—for example, higher levels of daily discrimination may heighten the already detrimental effect of ethnic discrimination on COVID-19 vaccination uptake. As such, an important direction for future research would be to explore the potential interaction between sociocultural stressors and how that interplay may influence Mexican-origin adolescents' COVID-19 vaccine uptake. Additionally, we utilized an adolescent-reported measure of economic status, which could differ from parent-reported assessments. Future studies should examine parent-reported measures of economic status as a sensitivity analysis to examine potential differences in the effect on adolescents' COVID-19 vaccine uptake. Related to measurement, we acknowledge that the study's measure of COVID-19 vaccine knowledge displayed lower, yet acceptable, reliability given the smaller number of items. Given the emergent nature of the COVID-19 pandemic, we could not benefit from the use of previously validated measures due to the unprecedented nature of this new public health threat. The measure of COVID-19 vaccine knowledge utilized within the study can still provide valuable insight into how this construct can be refined in future work, and guide researchers in conducting measurement work regarding this construct. Future research should also test whether the salience of challenges faced by Latino communities within the healthcare system could shape COVID-19 vaccination behaviors directly and/or indirectly *via* the KAB pathway (e.g., mistrust of medical professionals, dearth of culturally sensitive healthcare services, medical illiteracy), which were not examined within our analysis. In addition, the current study focused on Mexican-origin adolescents, which may limit the generalizability of findings to other Latino ethnic groups with sizeable populations in the U.S., such as those from Puerto Rico, the Dominican Republic, and Cuba. Future research aimed at developing effective strategies to combat health disparities in COVID-19 vaccine uptake should include other Latino ethnic groups, given the heterogeneous histories and cultures of Latino populations. Finally, given the large time gap between Wave 1 and 4 (i.e., nine years) and the requirement of meeting with an interviewer to complete the interview, a great proportion of adolescents had left the study by the time Wave 4 data collection commenced, which may cause sampling bias in the current study. Thus, the interpretation of study findings needs to be made with caution.

Despite the above limitations, this is one of the first few studies to investigate the longitudinal and concurrent associations between sociocultural factors and health knowledge, attitudes, and behaviors in Mexican-origin adolescents and young adults. Results may inform upcoming intervention efforts aimed at improving vaccination rates to combat future pandemics among not only Mexican-origin populations but also other Latino ethnic groups and ethnic minority populations that have faced persistent health inequalities. To effectively address discrimination against ethnic minority groups and their long-lasting mistrust of the U.S. healthcare system, it is crucial to ensure that accurate and culturally congruent information about vaccines and boosters is shared through trusted community leaders, advocacy groups, and community health workers (CHWs).[53] This is particularly important for adolescents, a vulnerable group that is sensitive to changes in their Knowledge-Attitude-Behavior process. Disseminating reliable information through these trusted channels can guide adolescents' knowledge and attitudes toward vaccines and boosters, ultimately leading to improved health behaviors.

Conclusions

The COVID-19 pandemic, compounded by the political climate following the public charge rule, continues to

fuel long-lasting health disparities in Latino communities. Study findings indicate that concurrent sociocultural stressors—including daily discrimination, foreigner stress, and economic stress—expose deep-rooted ethnic discrimination and racism against ethnic minorities that existed before the COVID-19 pandemic. These concurrent sociocultural stressors may influence the Knowledge-Attitude-Behavior process to contribute to low COVID-19 vaccine uptake rates among Mexican-origin adolescents. This is especially concerning given that Latinos are one of the most youthful and fastest growing demographics in the country. As such, effective public health campaigns aimed at improving vaccine uptake among Mexican-origin and other ethnic minority adolescents must consider the impact of concurrent, culturally situated stressors on the Knowledge-Attitude-Behavior process. More specifically, to enhance adolescents' knowledge and attitudes toward vaccines and boosters, which can ultimately lead to improved health behaviors, it is essential to disseminate reliable and culturally appropriate information through trustworthy community leaders, advocacy groups, and community health workers (CHWs). This is crucial in preparing for the ever-evolving COVID-19 pandemic and for future public health emergencies.

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Data availability statement

The data that support the findings of this study are available from the corresponding author, Su Yeong Kim, upon reasonable request.

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