Social Determinants of Health and COVID-19 Vaccination: An Individual Participant Data Meta-Analysis of Adult Latino Participants

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Acknowledgements. We gratefully acknowledge the members of the community advisory board and their contributions: María Paz Aguirre, BA; Judith Yáñez, MA; and Hannah Chaboya, BA. Research reported in this publication was supported by the Office of The Director (OD), National Institutes of Health (NIH) through the National Institute On Minority Health and Health Disparities under Award Number R21MD019396. Additional NIH support was provided by K23DC018033. The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH.

Abstract word count: 238
Main text word count excluding in-text references: 3,901
References: 45

Abstract

Objective: Although disparities in vaccination have been well documented, limited research has examined how specific Social Determinants of Health (SDOH) are associated with COVID-19 vaccination outcomes among Latino subgroups. The aims of the study are to investigate 1) the relative effects of distinct SDOH on reasons for and against vaccination among Latino adults and 2) how these effects may vary by language spoken at home.

Methods: A meta-analysis was conducted utilizing person- and study-level data from 13,406 Latino participants in the United States across 12 study samples from 2020-2023. Analyses evaluated SDOH effects on (a) reasons for and (b) against vaccination, as well as (c) the ratio of the two. Three SDOH were entered in a single model to compare their relative effect sizes: education, economic insecurity, and healthcare insecurity.

Results: Education and economic insecurity had the largest effect sizes compared to healthcare insecurity, which was not associated with outcomes. Greater economic insecurity was associated with more reasons against relative to reasons for vaccination. Spanish spoken at home moderated the effect of education levels, increasing both reasons for and against vaccination for highly educated participants, relative to non-Spanish speaking participants.

Conclusions: Findings inform future efforts aimed at reducing health disparities. The overall pattern of results suggests tailored interventions aimed at supporting COVID-19 vaccine attitudes in Latino communities should provide supports early and in accessible formats, particularly for communities with low educational levels and who use Spanish at home.

Keywords: Vaccines, COVID-19, Hispanic or Latino, Health Disparities, Social Determinants of Health, Attitude

Introduction

The COVID-19 pandemic caused and exacerbated many long-standing negative public health outcomes among minoritized communities. Such is the case among Latino communities in the United States, who experienced disproportionate COVID-19 burden compared to non-Latino Whites (Centers for Disease Control and Prevention, 2020; Fortuna et al., 2020; Rodriguez-Diaz et al., 2020) and, in some cases, other minoritized racial and ethnic communities (Murphy et al., 2021). By spring of 2021, COVID-19 vaccinations were becoming widely available, such that nearly half of Latino adults reported receiving a vaccine (Hamel et al., 2021). By 2023, despite the improved outcomes among Latinos as a whole, large proportions (approximately one-third; Hill et al., 2023) of Latinos did not get vaccinated due to barriers to vaccine access (e.g., lack of language access), misinformation, and fears toward and/or lack of confidence in the vaccine (Balasuriya et al., 2021).

A widely used approach to explaining health disparities frames differences in access to and use of preventive healthcare as a function of Social Determinants of Health (SDOH). Such theoretical models suggest systemic differences in SDOH, driven by racism, sexism, ableism, and other negative biases (Yearby, 2020), create health disparities. In the current study, we focus on three SDOH domains guided by the Healthy People 2030 Model (Healthy People 2030 et al., 2021): education, economic, and healthcare. Among Latinos, emerging literature corroborates the effects of these SDOH within the COVID-19 pandemic and on vaccination outcomes (e.g., Tai et al., 2022). For example, studies showed post-secondary **education** was generally positively associated with higher COVID-19 vaccination acceptance in Latino communities (Budd et al., 2024a; Kim, 2023). Similarly, **economic** SDOH are linked to vaccination outcomes, such that Latino persons with higher income showed higher vaccination acceptance and less

hesitancy (Carroll et al., 2022; Khubchandani & Macias, 2021; D. Kim, 2023). Regarding **healthcare** SDOH, qualitative interviews with Latino adults identified little-to-no health insurance coverage as a central barrier to COVID-19 vaccination (Perez et al., 2022), a finding corroborated by quantitative analyses showing access to medical providers increased the likelihood of vaccination among Latinos (Milo et al., 2023). Although these extant studies typically examined SDOH independently, taken together, they support the links between multiple SDOH and vaccination outcomes among Latinos.

A next step to advance empirical understanding of how SDOH distinctly relate to vaccination outcomes among Latinos is to test multiple SDOH domains in a single model. Doing so allows for comparison of strengths of the associations and the ability to identify the most important SDOH to each vaccination outcome. Such an approach would more precisely characterize how systemic conditions give rise to disparities in COVID-19 vaccination outcomes among Latinos and inform public health strategies to promote Latino engagement in this vital preventive healthcare.

Additionally, scholars have warned against characterizing Latinos as a monolith, ignoring the many factors that vary across Latinos (Ortiz et al., 2022; Weinick et al., 2004). For example, language barriers are frequently reported as sources of negative health outcomes, with emerging research demonstrating such barriers extend to testing and vaccination behaviors among Latinos during the COVID-19 pandemic (Bigelow et al., 2022; Buro et al., 2022; Jimenez et al., 2021). Data also suggest that interventions must be culturally and linguistically effective (Martinez et al., 2022), but it remains unknown which SDOH factors should be prioritized and for whom within the Latino community in the United States.

To our knowledge, only one study has tested and aimed to compare the strength of associations across SDOH domains to COVID-19 vaccination outcomes among subgroups of Latinos (Budd et al., 2024a, 2024b). That Oregon, United States-based study found education was positively associated with both reasons for and against vaccination. The study did not find significant differences in strength of associations across any of the SDOH significant to vaccination or testing outcomes, but it did find subgroup differences based on language access. The authors found language access moderated the effects of economic insecurity on vaccine hesitancy, such that the positive association of economic insecurity on vaccine hesitancy was heightened among those with lower English proficiency relative to those with higher English proficiency. How the study's results generalize across the United States is likely limited given differences between Oregon and other states (e.g., Oregon expanded Medicaid; Kaiser Family Foundation, 2023) and between the study's sample demographic characteristics and the United States Latino population (e.g., higher proportion of Latinos with Mexican origins and with no US-born parents in the Oregon sample compared to national data; Krogstad et al., 2022). Indeed, the demographics of Latino communities vary widely across the country, and favorable access to health-promoting SDOH differs as state policies govern a variety of systemic conditions. As such, there remains a need to compare SDOH associations with vaccination outcomes in a sample of Latino persons more representative of the national context.

The Current Study

The aims of the current study are to identify 1) the relative importance of educational, economic and healthcare SDOH on vaccination outcomes, specifically reasons for and reasons against vaccination, and 2) how these paths may vary by language access among Latino adults in the United States. This study will overcome limitations of past studies by pooling Latino

participant-level data from 12 geographically diverse Rapid Acceleration of Diagnostics (*RADx*, n.d.) Underserved Populations studies and comparing SDOH in a single model. Informed by extant literature, we hypothesize the educational SDOH will have the largest effect sizes on reasons for and reasons against vaccination relative to economic and healthcare SDOH. In addition, we expect language access will moderate SDOH associations with reasons for and against vaccination.

Method

Data Source

Data were extracted from the National Institutes of Health's RADx Data Hub repository (https://radxdatahub.nih.gov) developed and managed by the Duke Center for Data Collection and Coordination (CDCC; Carrillo et al., 2022; RADx-UP, 2024). Data for the present meta-analysis included responses to common survey measures from a total of 13,406 Latino participants collected from 12 independent study samples. These studies were chosen based on having >500 participants and >50% of participants who self-identified as Latino, with 78% of participants on average across studies identifying as such ("Are you of Hispanic, Latino, or Spanish origin?"). These parameters were enacted to increase the likelihood of variability within the data and produce an ample sample size to control for auxiliary covariates across studies (e.g., sampling strategy, study site setting). Data were collected between December 2020 through August 2023 from study sites in California, Florida, Maryland, New York, North Carolina, Oregon, and Washington. Data were analyzed in accordance with the World Medical Association Declaration of Helsinki. Ethical principles for medical research involving human subjects and procedures were approved by the appropriate institutional review boards and privacy rights observed.

Measures

All person- and site-level measures were provided by the CDCC (Carrillo et al., 2022) and required data collection by the 12 studies in this meta-analysis (see Supplemental Materials for measures and sources). The three outcome variables were reasons for and against vaccination and their ratio. Reasons for vaccination was assessed with one question, "Why would you get a COVID-19 vaccine?" and a checklist of 10 items (e.g., *I don't want to get really sick from COVID-19*), plus an Other option. Reasons against vaccination (concerns) was assessed with one question, "Why would you NOT get a COVID-19 vaccine?" and a checklist of nine items (e.g., *I don't trust the vaccine will be safe*), plus an Other option. Participants checked corresponding boxes of items they endorsed. Sum scores were calculated by counting the total number of reasons endorsed for and against vaccination, respectively, with a possible range of 0 to 11 for each of the two measures. As a related but distinct measure of hesitancy, a third measure was the ratio of reasons against relative to the reasons for vaccination, with higher scores reflecting a greater ratio of reasons not to get vaccinated.

The three independent SDOH variables included education, economic insecurity, and healthcare insecurity. Educational attainment was measured in six binned categories ranging from 0 to 5: 0 "Have never gone to school", 1 "Some school", 2 "High school graduate", 3 "Some college", 4 "Bachelor's degree" and 5 "Other advanced degree" (Master's, Doctorate or Professional Doctorate). Economic insecurity was measured by a summative index from 0 to 8, comprised of 4 items (e.g., *Having a place to stay/live*) rated 0 "No, not a challenge," 1 "Yes, a minor challenge," and 2 "Yes, a major challenge." Higher scores indicated greater economic insecurity. Healthcare insecurity was a summative index of three items ranging from 0 to 5. Two items (e.g., *Getting the medicine I need*) measured challenges with the same response scale as

economic insecurity. The third indicator was a binary (*Yes, No*) measure indicating whether the participant lost health insurance due to the pandemic.

Participant characteristics including age (in years), sex, and date of data collection (pandemic phase) were additional independent variables. For sex, the category "female" was defined as self-reported sex assigned at birth from most studies, and gender identity in other studies was used as a proxy. This approach has limitations given that sex and gender overlap but are not interchangeable, but it permitted analysis given that all 12 studies did not have biological sex reported and all 12 did not have gender identity reported. In the current analysis, a participant was considered female if they indicated biological sex was female or, if biological sex was not asked but they identified their gender as female or woman. It was coded 1 for female and 0 for non-female. Language, specifically whether the participant reported speaking Spanish at home (*Yes, No*), was an independent variable in Study Aim one and hypothesized moderator in Study Aim two. Study-level descriptors included whether the study site where participants visited to complete the survey was in a clinic or community setting, and whether SARS-CoV-2 testing and/or COVID-19 vaccination were offered. Pandemic phase represented the time or wave of the pandemic at which the respondent's data were collected. Pandemic wave included dates of variant peak phases (Corum & Zimmer, 2021): Epsilon - participants sampled before March 2021; Alpha - March 1, 2021 to June 15, 2021; Delta - June 16, 2021 to December 15, 2021; Omicron - December 16, 2021 to March 31, 2022; Omicron B variant - April 1, 2022 to Aug 31, 2022; and Omicron B variant Plus – on or after September 2022.

Data Preparation and Analysis Plan

Missing data were imputed using a Bayesian Markov Chain Monte Carlo approach with the *pan* package (Multiple Imputation for Multivariate Panel or Clustered Data; Grund et al.,

2016). In total, 12 data sets were imputed with 10,000 burn-ins and 1,000 iterations for each completed dataset. Prior to imputation, to address the relative contribution of SDOH predictors and tests of moderation, binary data were effects coded to -1 and 1, and scale and integer data were mean centered and standardized. The model was predicted with the study variables and demographic characteristics of each sample. Missing data ranged from 8 to 36 percent (mean = 18%, median = 16%), below the recommended level (>40%) for excluding multiple imputation (Jakobsen et al., 2017). Data were not found to be missing completely at random (MCAR), and were assumed to missing at random (MAR) and imputed.

Analyses involved individual participant data meta-analysis. More specifically, hypotheses were tested using meta-regression meta-analysis (Harrer et al., 2021), a.k.a., multilevel or mixed model regressions to address clustering of participants from the 12 independent study samples. The mixed-effects model for predicting reasons against vaccination was specified as:

$$\textit{Reasons Against Vaccination} = \gamma_{00} + \gamma_{1\,0}(\textit{education}) + \gamma_{2\,0}(\textit{economic insecurity}) + \gamma_{3\,0}(\textit{healthcare insecurity}) + \gamma_{4\,0}(\textit{Alpha}) + \gamma_{5\,0}(\textit{Delta}) + \gamma_{6\,0}(\textit{Omicron}) + \gamma_{7\,0}(\textit{Omicron B}) + \gamma_{8\,0}(\text{Omicron B plus}) + \gamma_{9\,0}(\textit{Spanish language home}) + \gamma_{10\,0}(\textit{female}) + \gamma_{11\,0}(\textit{age}) + \gamma_{0\,1}(\textit{clinic}) + \gamma_{0\,2}(\textit{testing offered}) + \gamma_{0\,3}(\textit{vaccine offered}) + u_0 + r$$

Where, the summative scale for reasons against, reasons for, or ratio of reasons against to reasons for vaccination is a function of an overall intercept γ_{00} and is regressed on Level one - person level predictors (education the $\gamma_{1\,0}$ parameter, economic insecurity $\gamma_{2\,0}$, and healthcare insecurity $\gamma_{3\,0}$), pandemic phase in which the participant completed the survey were the effects of $\gamma_{4\,0}$ to $\gamma_{8\,0}$, and the level 1 intercept is adjusted for individual characteristics (Spanish spoken in home $\gamma_{9\,0}$, female $\gamma_{10\,0}$, and age $\gamma_{11\,0}$). At level two, the intercept is adjusted for study site level characteristics; whether the study was a clinic setting $\gamma_{0\,1}$, a testing site $\gamma_{0\,2,}$ or a site where a

vaccine was offered at the time of study data collection $\gamma_{0\,3}$. The fixed effects model includes a random intercept across study sites u_0 plus a residual r. Analyses were conducted in R with the *pan* and *lme4* packages and tested with a two-tailed alpha level of .05 (Bates et al., 2024). This manuscript was drafted in accordance with STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines (von Elm, et al., 2007).

Results

Table 1 includes descriptive statistics of the Latino participant characteristics (mean age = 42.3 ± 15.5 years, min = 18, max = 90; 65.9% female; 70.8% speak Spanish at home; 59.8% high school/GED or less education) and study site characteristics (56.6% community or other non-clinic setting; 92.1% offered SARS-CoV-2 testing; 16.6% offered COVID-19 vaccination). Table 2 includes descriptive statistics on SDOH and outcome variables, whereas results evaluating the SDOH model are presented as standardized effects in Table 3. Overall, effect sizes for predictors (r) ranged from .01 to .15, showing differences in the magnitude of association. Table 4 reports the missing number of participants for each variable of interest.

Starting with the hypothesized SDOH domains as predictors, higher levels of education predicted more reasons against vaccination (γ = .03, p = .03) and more reasons for vaccination (γ = .10, p < .05). Additionally, higher levels of education were associated with fewer reasons against relative to reasons for vaccination (γ = -.05, p < .05). That is, although participants with higher levels of education endorsed both more reasons against and reasons for vaccination, when considering the balance of the two, higher educated participants endorsed more reasons for vaccination than concerns. Economic insecurity did not predict reasons against vaccination but was associated with fewer reasons for vaccination (γ = -.04, p = .01). Similarly, economic

insecurity was associated with more reasons against vaccination relative to reasons for (γ = .04, p = .03). Healthcare insecurity was not associated with either vaccination outcome.

Among individual characteristics, females reported more reasons against and more reasons for vaccination relative to male participants (γ = .04, p <.05 and γ = .02, p =.02, respectively). Older participants reported fewer reasons against vaccination (γ = -.08, p <.05), more reasons for vaccination (γ = .09, p <.05), and overall less reasons against relative to reasons for vaccination (γ = -.09, p <.05), than younger participants. Clinic setting and testing and vaccine availability were not significant predictors. Like education, participants speaking Spanish at home reported more reasons against (γ = .09, p < .05), more reasons for vaccination (γ = .17, p < .05); and overall, fewer concerns to reasons (γ = -.11, p <.05). Across the pandemic phases, relative to the onset of the pandemic, there were generally more reasons against and reasons for vaccination over time, and overall fewer concerns relative to reasons for vaccination for all phases except Alpha relative to Epsilon, the omitted category.

Tests of language access showed Spanish home language use moderated the effect of education on both reasons against vaccination (γ = .03, p =.03) and reasons for vaccination (γ = .02, p = .05). The simple slopes for the moderator are illustrated in Figure 1. That is, for those who speak Spanish at home and are more educated, there was greater endorsement of reasons for and against vaccination relative to participants who do not speak Spanish at home. Unlike education, Spanish home language use did not moderate economic and healthcare insecurity SDOH.

Discussion

The innovation of the current study lies in its a) ability to directly compare educational, economic insecurity, and healthcare access SDOH in a single model and b) do so within a meta

sample of only Latinos created by pooling 12 study samples. The meta sample better reflects the breadth of diversity within the United States Latino population than any of the individual study samples reflecting a single geographic community and state. The pattern of finding reveals that among SDOH, *Spanish home language use* and its amplification of *educational* effects on reasons for and against vaccination showed the strongest association with vaccine outcomes (reasons against and for vaccination, and the relative balance of the two). Further, across all individual predictors evaluated, *pandemic wave* had the strongest association with vaccine outcomes (reasons against and for vaccination, and the relative balance of the two).

Specifically, the study findings were consistent with our first hypothesis that education would be most strongly associated with all three vaccination outcomes. Among the three SDOH evaluated, education indeed had the strongest effects. However, findings showed that the phase of the pandemic had the strongest association (largest effect size) with reasons against vaccination and the ratio of reasons against to the reasons for vaccination when considering all independent variables in the model. That is, Latinos may have differential exposure to health-related information based on education, and the quality and content of the information can further vary and lead to both greater acceptance and rejection, reiterating the importance of understanding both hesitancy and acceptance simultaneously. Information on where and how to find credible evidence-based information should be a priority for public health campaigns and educators. This is especially important given the rapidly evolving guidance in a pandemic context and suggests that a focus on identifying high quality guidance is equally as important as sharing guidance itself.

Across the pandemic phases, there was greater endorsement of reasons for and against vaccination over time. However, as time passed, the concerns relative to reasons for vaccination

decreased numerically. Potentially, the increasing availability of data-supported vaccine information over time supported learning and confidence in the vaccine, especially for persons with greater educational levels. This reflects emerging evidence of the larger environmental context's (in this case, pandemic phase) link to vaccination information and attitudes in Latinos. Indeed, longitudinal effects on vaccine attitudes during the COVID-19 pandemic have also been documented in majority White populations (Fridman et al., 2021).

Our second hypothesis was supported by the study findings, such that language access significantly moderated—with large effect sizes—reasons for and against vaccination. Specifically, the main effect of educational SDOH showed higher education level was associated with more reasons for and against vaccination, but higher education level also predicted relatively fewer reasons against than for vaccination. These findings are consistent with the general body of evidence among SDOH showing greater educational levels favoring better engagement in health services, including studies of COVID-19 vaccine uptake among Latinos (Budd et al., 2024b; Kim, 2023). Moreover, the analyses revealed Spanish home language moderated the effect of education, such that the association between education and reasons for and against vaccination was greatest among those who speak Spanish at home relative to those who do not. This moderation indicates that subgroups of Latinos, particularly those with low education and Spanish home language use, are more likely to endorse concerns and reasons for vaccination overall. The moderation of Spanish spoken at home underscores the reoccurring point raised in prior literature, that language matters for accessing information on vital health services, like vaccination. Mounting evidence shows that populations with limited English proficiency, like many Spanish speakers, were disproportionately affected by the pandemic due to language barriers in health systems (Himmelstein et al., 2022; Kim et al., 2020; Kucirek et al.,

253 2021). Those who prefer Spanish had some of the highest COVID-19 rates compared to other
254 groups (Kim et al., 2020). Yet, an analysis of health department websites across 10 of the largest
255 cities in the United States found Spanish-language pages were absent or inferior across a variety
256 of metrics compared to English resources (Kusters et al., 2023).

257 Regarding economic and healthcare SDOH, effect sizes were smaller or nonexistent
258 compared to effects of pandemic phase, education, and the moderation of language access
259 reviewed above. Main effects showed economic *in*security is associated with less endorsement of
260 reasons for vaccination and a greater proportion of concerns to reasons for vaccination compared
261 to those with economic security. Economic effects are some of the most commonly observed
262 among studies of SDOH, with published findings among Latinos extending to COVID-19
263 vaccine outcomes (Carroll et al., 2022; Khubchandani & Macias, 2021). The results of this study
264 extend our understanding by showing that although economic insecurity is associated with more
265 reasons to get vaccinated among Latinos, the degree of economic insecurity means that those
266 experiencing the greatest economic challenges have generally more concerns relative to reasons
267 for vaccination. Moreover, healthcare insecurity did not show significant associations with
268 vaccine attitudes in the current study. Prior research shows mixed findings regarding healthcare
269 insecurity/access and COVID-19 vaccine outcomes. Though Latinos reported having health
270 insurance as a facilitator of vaccination in one qualitative study (Perez et al., 2022), and access to
271 healthcare providers predicts vaccination in Latino groups (Milo et al., 2023), the effect of
272 healthcare insecurity is not replicated in analyses like the current study that include all SDOH
273 domains in a single model. For example, in a study of Latinos in Oregon, healthcare access was
274 evaluated along with other SDOH in the same model, and healthcare access did not predict
275 testing or vaccination outcomes (Budd et al., 2024b). The lack of an effect of healthcare

insecurity should not be taken to mean it does not matter for vaccination attitudes generally. Instead, the current study's analyses suggest healthcare insecurity is less important to vaccination attitudes compared with other SDOH among Latinos. Considering that access to healthcare settings was limited during the pandemic due to concerns about mitigating COVID-19 exposure, it may be the relative availability of information about COVID-19 vaccines and various targeted efforts through media campaigns to share health information that attenuated healthcare access barriers compared to other vaccination contexts (DeGarmo et al., 2022).

Taken together, these findings suggest there is room for more targeted messages that address concerns and promote confidence in vaccination and are shared *early* in a public health emergency. The messages also need to be shared in *languages that are accessible* for non-English speakers and responsive to low literacy levels to better serve Latinos with *low education*. Moreover, economic insecurity was significant, meaning "free" and readily accessible vaccines for low-income Latinos through government subsidies continue to be meaningful interventions. Nevertheless, given the relative importance of the different SDOH examined in the current study, organizations can prioritize those factors that have the greatest impact (i.e., effect sizes) when resource limitations are especially constrained. Importantly, these findings reflect the context of a global pandemic, though findings may translate to other vaccine-preventable communicable diseases (e.g., influenza), future epidemics or pandemics, and continued COVID-19 preventive services like booster vaccinations. Lastly, it will be important to implement such targeted efforts in a manner that avoids confusion and misinformation, a phenomenon that was exacerbated among Latinos during the COVID-19 pandemic (Soto-Vásquez et al., 2021).

Limitations

Although there were benefits to using an existing repository to create a large sample of Latino participants, there were limitations based on available data. For example, language barriers are often best indexed by English language proficiency, but Spanish spoken at home was the best available variable. Additionally, the analytic model is missing social and environment SDOH because no measures of variables reflecting these domain (e.g., discrimination, social support, neighborhood information) were required common data elements across the RADx-UP studies. This is especially unfortunate, as discrimination is a salient SDOH linked to engagement with health services and health outcomes among Latino (Cano et al., 2021; Molina et al., 2019) and other marginalized populations. Nevertheless, the pattern of findings corroborates an emerging picture about SDOH and Latino subgroup differences that can guide hypothesis testing in future research. Similarly, future research should focus on marginalized groups within the Latino community, including gender-expansive communities (Miranda, Perez-Brumer, & Charlton, 2023). Moreover, there were limitations to data availability for important participant level characteristics such as sex and gender that made the inclusion of these variables limited in validity in the current study and an area for future research to increase rigor.

Conclusion

The current study directly compared SDOH and evaluated their relative importance on vaccine outcomes among Latinos to inform future public health efforts. Pandemic wave, education, and Spanish language use at home had the largest effects on reasons for and against vaccination. Data suggest addressing concerns and promoting vaccination confidence early in a pandemic and in an accessible language, particularly for communities with low education levels, is a meaningful first step for serving Latinos at disproportionate risk for poor health outcomes.

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Author contributions

Stephanie De Anda: Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Visualization, Writing – original draft, Writing – review & editing. **Elizabeth L. Budd:** Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Visualization, Writing – original draft, Writing – review & editing. **Pimwadee Chaovalit:** Data curation, review & editing. **Amy H. Vu:** Investigation, Writing – review & editing. **Leslie D. Leve:** Conceptualization, Writing – review & editing. **David DeGarmo:** Data curation, Formal analysis, Methodology, Supervision, Visualization, Writing – original draft, Writing – review & editing.

Disclosure of funding and conflicts of interest

The authors have no possible perceived, or real financial conflicts of interest or partnership with commercial interest. Research reported in this publication was supported by the Office of The Director, National Institutes of Health (NIH) through the National Institute On Minority Health and Health Disparities under Award Number R21MD019396. Additional NIH support was provided by K23DC018033. The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH.

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