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Short communication

Vaccine hesitancy relates to vaccine hesitancy? Discovering nonlinear relations between differing operationalizations of vaccine hesitancy

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ABSTRACT

Objectives: Vaccine hesitancy is often conceptualized as negative perceptions regarding vaccines, but recent authors have increasingly argued that the construct should instead be conceptualized as indecision in the vaccination decision-making process. This has caused authors to reevaluate the placement of vaccine hesitancy in associated models and frameworks, and it has caused uncertainty regarding how these two conceptualizations relate to each other. In the current article, we argue that the relation between these two conceptualizations of vaccine hesitancy is best understood via nonlinear effects. Specifically, we argue that this relation takes an inverted U-shape.

Study design: We utilized a cross-sectional survey design.

Methods: We recruited 273 participants from Prolific who completed two measures of vaccine hesitancy: an eight-dimension measure reflecting negative perceptions of vaccines and a unidimensional measure reflecting indecision in the vaccine decision-making process.

Results: We performed eight quadratic regression analyses (one for each dimension) to assess our proposed nonlinear relation. The quadratic term was significant in all eight regression analyses (all $p < .01$), supporting our proposed inverted U-shape relation.

Conclusions: Our results provide reasoning for future authors to test whether vaccine hesitancy as negative perceptions impacts vaccination via vaccine hesitancy as indecision, and researchers must now recognize their nonlinear relation in any developed models and frameworks.

1. Introduction

Vaccine hesitancy is often conceptualized as negative perceptions regarding vaccines,[1,2] which is reflected in a multitude of operationalizations including the Multidimensional Vaccine Hesitancy Scale (MVHS);[3] however, recent authors have increasingly argued that the construct should instead be conceptualized as indecision in the vaccination decision-making process,[4,5] resulting in the development of the Unidimensional Vaccine Hesitancy Scale (UVHS).[6] This shift in perspective has caused authors to reevaluate the placement of vaccine hesitancy in associated models and frameworks, and it has caused uncertainty regarding how these two conceptualizations relate to each other. As both conceptualizations influence vaccination behaviors, it is important to correctly model both within associated models and frameworks.

In the current article, we argue that the relation between these two conceptualizations of vaccine hesitancy is best understood via nonlinear effects. People with very low negative perceptions or very high negative perceptions about vaccines are not indecisive about vaccination; they are likely to have made their decision to be vaccinated or not. Those who have moderate levels of vaccine hesitancy are most likely to be indecisive about vaccination, resulting in the relation of vaccine hesitancy as negative perceptions to produce an inverted U-shape relation with vaccine hesitancy as indecision. That is, people with the least and most negative perceptions of vaccines are expected to be the least indecisive about vaccination, whereas those with moderate negative perceptions of vaccines are expected to be the most indecisive about vaccination. We test this possibility by analyzing the nonlinear relation between the MVHS dimensions (defined in Supplemental Material A Table 1) and the UVHS. By doing so, we uncover presently untested nonlinear effects, providing clarity to authors regarding how to place these two conceptualizations of vaccine hesitancy in associated models and frameworks.

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2. Methods

2.1. Transparency statement

Our dataset is provided as Supplemental Material B.

2.2. Participants

Participants (Age $\bar{x} = 39.91$, Age S.D. = 13.85, 54 % Female, 100 % United States) were recruited from Prolific in return for monetary compensation. Prolific is an online platform connecting those who need small tasks completed, such as taking a survey, with those willing to complete the tasks. Prior studies have supported the validity of results obtained via Prolific when taking the precautions of the current study.[7,8] We administered three attention checks, and we removed participants that failed more than one. This resulted in the removal of 4 participants, producing a final sample size of 273 participants.

Further, 200 of these participants participated in Study 3 of Howard (2024).[6] We conducted a power analysis to determine the necessary sample size to test our effects ($1 - \beta = .80$, $\alpha = .05$, $f^2 = .05$), which recommended a minimum sample size of 262. For this reason, we collected 73 more participants (in addition to the 200) utilizing the same research methodology as Study 3 of Howard (2024),[6] which met the minimum set by our power analysis and produced our final sample size ($n = 273$). When including a dummy-coded variable to control for whether the participant was part of the original sample, the inferences produced by our results did not change. We report our analyses without this dummy-coded variable, and this alternative analysis can be provided upon request.

2.3. Procedure

Participants enrolled via the Prolific platform. They were provided with an information sheet and indicated their willingness to participate. They then completed the online survey. Afterwards, they were thanked for their time and told the purpose of the study.

2.4. Measures

MVHS. We administered the MVHS of Howard (2022).[3] This scale includes four items for each of eight dimensions, which are defined in Supplemental Material A Table 1. An example item is, "Vaccines cost too much" (Cost). Participants responded on a 1 (Strongly Disagree) to 7 (Strongly Agree) response format.

UVHS. We administered the UVHS of Howard (2024).[6] This scale includes four items, and an example item is, "I am generally undecided about receiving vaccines." Participants responded on a 1 (Strongly Disagree) to 7 (Strongly Agree) response format.

3. Results

Supplemental Material A Table 2 provides correlations and Cronbach's alphas. The UVHS produced a significant and positive linear relation with each dimension of the MVHS, with correlations ranging from .17 to .47 (all $p < .01$). We performed eight separate quadratic regression analyses using heteroskedasticity-consistent standard errors

Table 1
Quadratic regression results.

	β	β	β	β	β	β	β	β	β
1a.) HR	0.59**								0.35*
	−0.27**								−0.06
1b.) HR^2		0.30**							−.07
2a.) Cost		−0.24**							−0.01
2b.) Cost^2			0.24**						0.01
3a.) PP			−0.16*						0.03
3b.) PP^2				0.53**					0.02
4a.) Incov				−0.28**					0.00
4b.) Incov^2					0.84**				0.45**
5a.) PR					−0.52**				−0.34**
5b.) PR^2						0.60**			0.17
6a.) Acc						−0.34**			−0.06
6b.) Acc^2							0.64**		0.06
7a.) Heal							−0.40**		−0.13
7b.) Heal^2								0.47**	0.17
8a.) Forg								−0.26**	−0.01
8b.) Forg^2									
R^2	0.27**	0.09**	0.05**	0.18**	0.29**	0.14**	0.22**	0.16**	0.42**

Note. For each regression analysis, no VIF value was above the standard cutoff of five. An a priori power analysis indicated that a minimum sample size of 262 was necessary for our most demanding analysis, and our sample size of 273 exceeded this value. All regression analyses conducted with heteroskedasticity-consistent standard errors (HC3). UVHS = Unidimensional Vaccine Hesitancy Scale, HR = Health Risks, PP = Physical Pain, Incov = Inconvenience, PR = Personal Reactions, Acc = Accessibility, Heal = Healthy, Forg = Forget.
*p < .05.
**p < .01.

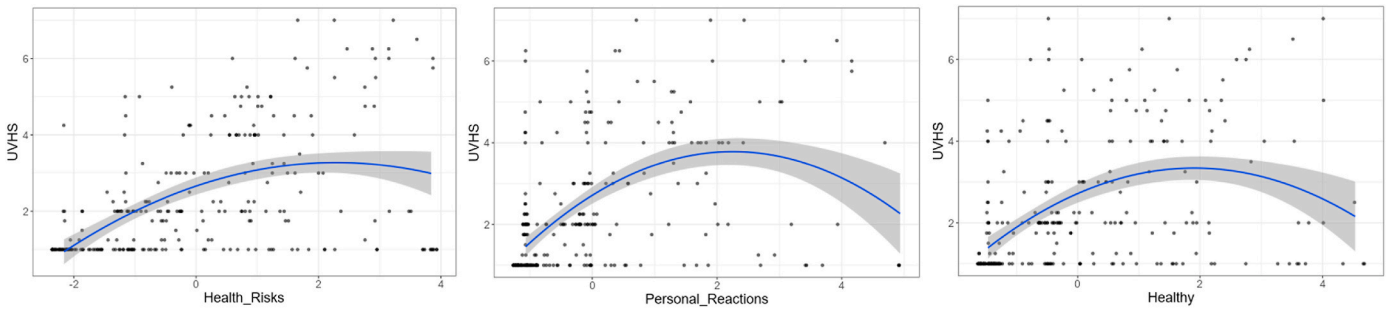

Fig. 1. Visual representations of polynomial relations between three Multidimensional Vaccine Hesitancy Scale dimensions and the Unidimensional Vaccine Hesitancy Scale.
Note: First figure represents the relation between the dimension of Health Risks and the Unidimensional Vaccine Hesitancy Scale. The second figure represents the relation between the dimension of Personal Reactions and the Unidimensional Vaccine Hesitancy Scale. The third figure represents the relation between the dimension of Healthy and the the Unidimensional Vaccine Hesitancy Scale.
Alt Text: The figure present three charts demonstrating an inverted U-shape relation between three dimensions of the Multidimensional Vaccine Hesitancy Scale and the Unidimensional Vaccine Hesitancy Scale. The three dimensions are Health Risks, Personal Reactions, and Healthy, which are defined in Supplemental Material A.

(HC3) to assess the nonlinear relation of each MVHS dimension with the UVHS (Table 1). To conduct these analyses, we mean-centered each predictor, squared each predictor to create the quadratic term, and entered both the original term and the quadratic term into the regression analysis. The variance inflation factor (VIF) statistic of each predictor in all regression analyses, including the omnibus analysis, was below the standard cutoff of five, indicating that multicollinearity is not an issue in our analyses.[9]

The quadratic term was significant in all eight regression analyses (all $p < .01$), supporting our proposed nonlinear relation. Fig. 1 provides visual representations of three selected relations. Lastly, we conducted an omnibus regression analysis with the linear and quadratic terms of all eight MVHS dimensions predicting the UVHS (Table 1). While the reliability of this analysis is unclear due to the very large number of included quadratic terms, the result found that the linear effect of Health Risks ($p = .03$) and Personal Reactions ($p < .01$) were statistically significant, and the quadratic effect of Personal Reactions was also statistically significant ($p < .01$).

4. Discussion

The goal of the current article was to provide clarity regarding the relation of two separate conceptualizations of vaccine hesitancy, one as negative perceptions regarding vaccines (MVHS) and the other as indecision in the vaccination decision-making process (UVHS). Our results supported that each dimension of the MVHS produced a nonlinear relation with the UVHS in the hypothesized manner, an inverted U-shaped relation. Participants had weaker indecision in the vaccine decision-making process when their negative perceptions regarding vaccines were either lower or higher, whereas they had stronger indecision in the vaccine decision-making process when their negative perceptions regarding vaccines were moderate. This result poses several implications for both research and practice.

First, because vaccine hesitancy as indecision is an immediate antecedent to vaccination behaviors,[4,6] our results provide reasoning for future authors to test whether vaccine hesitancy as negative perceptions impacts vaccination via vaccine hesitancy as indecision, providing greater justification for its placement in models and frameworks. Future researchers should test for this mediating effect, and if supported, novel models would need to be developed that account for both types of vaccine hesitancy. In doing so, researchers must recognize their nonlinear relation, adding further consideration to the complexity of vaccination behaviors.

Second, extant models when applied to study vaccination, such as the Health Belief Model,[10] must be revised to account for both conceptualizations of vaccine hesitancy and their nonlinear relation. For example, the Health Belief Model,[9] includes the primary antecedents to health behaviors of perceived susceptibility, perceived severity, perceived benefits, and perceived barriers. In the study of vaccination behaviors, vaccine hesitancy is most often included among these primary antecedents. This is because authors have often applied the conceptualization of vaccination as negative perceptions in conjunction with the Health Belief Model,[9] and the primary antecedents within this model are negative perceptions themselves. Our study suggests, however, that vaccine hesitancy as indecision should be included as an additional link in the potential causal chain between the modeled primary antecedents and vaccination behaviors, as this state of indecision may be even more proximal to vaccination behaviors. In turn, the inclusion of this additional construct provides greater nuance to understanding the cognitive mechanisms that occur when determining whether to receive vaccines, and other models could be similarly revised to account for multiple conceptualizations of vaccine hesitancy.

Third, our results encourage future researchers to test whether alternative predictors produce nonlinear relations with vaccine hesitancy as indecision, as our applied theoretical rationale can likely generalize to other constructs. Many frameworks exist to understand the barriers to receiving vaccines, such as the 7C model.[11] It is likely that the logic applied to test the present relations of two conceptualizations of vaccine hesitancy could also apply to these other frameworks. For instance, those who perceive low or high barriers associated with the 7C model may again be relatively unlikely to be indecisive about vaccination, as they are firmly willing or not willing to be receive vaccines; however, those who perceive moderate barriers may be the most indecisive. Thus, the present article can provide a broadly applicable lens to understand the relations of antecedents and vaccine hesitancy as indecision.

Fourth, the limitations of our work offer directions for future research. Perhaps most notably, the current article utilized a cross-sectional research design. While analyses indicated that common method bias was not a concern with our results (provided upon request), future researchers should nevertheless replicate the current results while utilizing more robust research designs, such as panel designs. Likewise, we utilized a supported platform to collect our sample, but future researchers should pursue other approaches to obtain representative samples. By doing so, the broader generalizability of our findings could be further supported.

Author statements

Ethical approval

All procedures were approved by the IRB of the primary author's institution.

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Competing interests

The authors have no competing interests to declare.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2025.01.012.

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