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Association of moral values with vaccine hesitancy

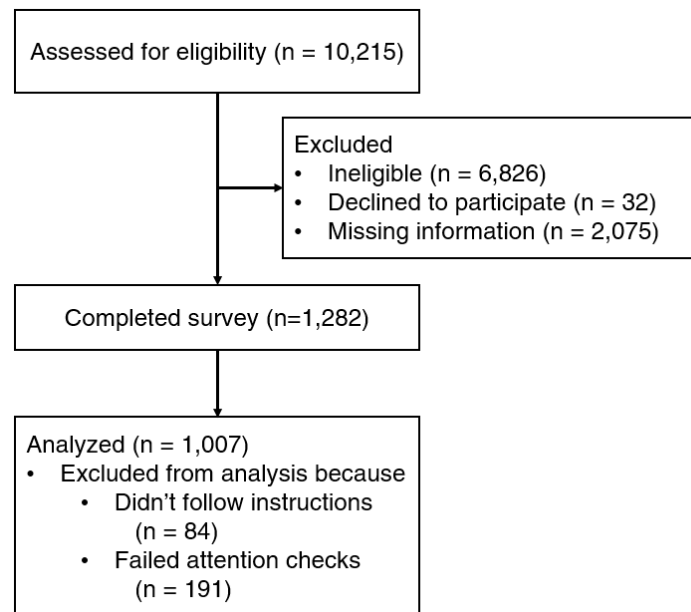
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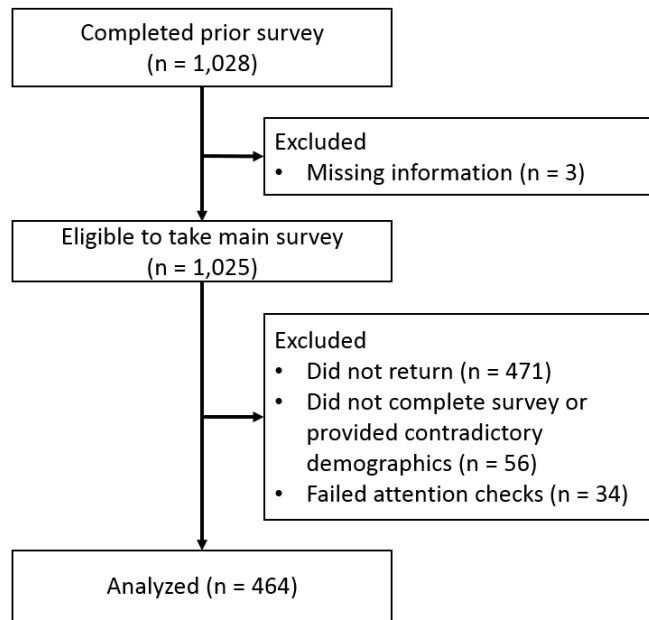
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Supplementary Figure 1. Participant flow diagram depicting the number of individuals who were assessed for eligibility, completed the survey, and provided data used in the final analysis for Study 1.



Supplementary Figure 2. Participant flow diagram depicting the number of individuals who were assessed for eligibility, completed the survey, and provided data used in the final analysis for Study 2.

Supplementary Tables

Supplementary Table 1. Selected sociodemographic characteristics of the study population from Study 1 (n = 1,007).

Characteristics*	N (%)
Gender	
Male	338 (33.6)
Female	669 (66.4)
Age	
18-40 years old	771 (76.6)
41+ years old	236 (23.4)
No. of children	
1	404 (40.1)
2	363 (36.1)
3	149 (14.8)
4	61 (6.1)
5+	30 (3.0)
Education	
High school at most	97 (9.6)
Some college	307 (30.5)
College degree	392 (38.9)
Some graduate school	61 (6.1)
Graduate-level degree	150 (14.9)
High moral foundation endorsement	
Authority/subversion	553 (54.9)
Fairness/cheating	558 (55.4)
Harm/care	537 (53.3)
Loyalty/betrayal	545 (54.1)
Purity/degradation	535 (53.1)
Liberty/oppression	493 (49.0)
Strength of vaccine hesitancy	
Low	735 (73.0)
Medium	115 (11.4)
High	157 (15.6)
Political ideology	
Conservative	313 (31.1)
Moderate	174 (17.3)
Liberal	420 (41.7)
Libertarian	35 (3.5)
Other/Don't Know	65 (6.5)

*Note that percentages may not sum to 100 due to rounding.

Supplementary Table 2. Selected sociodemographic characteristics of the study population from Study 1, stratified by level of vaccine hesitancy according to the Parent Attitudes about Childhood Vaccines short scale (n = 1,007).

Characteristics*	Low Hesitancy (n = 735)	Medium Hesitancy (n = 115)	High Hesitancy (n = 157)	p-value**
Gender				0.37
Male	34.4	34.8	28.7	
Female	66.6	66.2	71.3	
Age				0.12
18-40 years old	78.1	74.8	70.7	
41+ years old	21.9	25.2	29.3	
No. of children				<0.01
1	41.4	39.1	35.0	
2	37.4	38.3	28.0	
3	13.7	15.7	19.1	
4	5.6	3.5	10.2	
5+	1.9	3.5	7.6	
Education				<0.01
High school at most	8.5	11.3	14.0	
Some college	27.5	40.0	37.6	
College degree	40.5	31.3	36.9	
Some graduate school	6.4	5.2	5.1	
Graduate-level degree	17.1	12.2	6.4	
Political ideology				<0.01
Conservative	30.8	31.3	31.9	
Moderate	15.7	17.4	24.8	
Liberal	45.3	36.5	28.7	
Libertarian	2.7	1.7	8.3	
Other/Don't Know	5.4	13.0	6.4	

*Note that percentages may not sum to 100 due to rounding.

** p-values estimated using a Monte Carlo simulation. None of the 95% confidence intervals contained 0.05.

Supplementary Table 3. Odds ratios, 95% confidence intervals, and p-values for a no-interaction unconditional polytomous logistic regression model (Model 1A); adjusted for age and education; developed in Study 1.

Moral Foundation	Medium vs. Low Hesitancy			High vs. Low Hesitancy		
	aOR	95% CI	p-value	aOR	95% CI	p-value
High endorsement of authority	0.89	0.53, 1.51	0.67	0.43	0.27, 0.67	<0.01*
Low endorsement of authority	Ref.	-	-	Ref.	-	-
High endorsement of fairness	1.16	0.74, 1.80	0.52	1.00	0.67, 1.48	0.98
Low endorsement of fairness	Ref.	-	-	Ref.	-	-
High endorsement of harm	0.84	0.54, 1.31	0.43	1.06	0.71, 1.59	0.77
Low endorsement of harm	Ref.	-	-	Ref.	-	-
High endorsement of loyalty	1.30	0.79, 2.14	0.30	0.95	0.62, 1.46	0.81
Low endorsement of loyalty	Ref.	-	-	Ref.	-	-
High endorsement of purity	2.08	1.27, 3.40	<0.01*	2.15	1.39, 3.31	<0.01*
Low endorsement of purity	Ref.	-	-	Ref.	-	-
High endorsement of liberty	0.99	0.65, 1.50	0.96	2.19	1.50, 3.21	<0.01*
Low endorsement of liberty	Ref.	-	-	Ref.	-	-

*Statistically significant (p < 0.05)

Supplementary Table 4. Unstandardized beta coefficients, standard errors, and p-values for a no-interaction, multiple linear regression model developed in Study 1. The outcome is Parent Attitudes about Childhood Vaccines short scale scores (0-10). Predictors include moral foundation scores (0-30), education, and age (18-50).

Predictor	b	SE	p-value
Authority*	-0.155	0.026	<0.0001
Fairness	-0.016	0.025	0.519
Harm	0.004	0.023	0.856
Loyalty	0.012	0.023	0.604
Purity*	0.126	0.017	<0.0001
Liberty*	0.130	0.022	<0.0001
Age*	0.039	0.012	0.001
Education			
Some college	-0.301	0.319	0.346
College graduate*	-0.856	0.312	0.006
Some graduate school	-0.711	0.451	0.115
Graduate degree*	-1.537	0.364	<0.0001
High school at most	Ref.	-	-

*Statistically significant ($p < 0.05$).

Supplementary Table 5. Odds ratios, 95% confidence intervals, and p-values for a no-interaction unconditional polytomous logistic regression model; adjusted for age, education, and political ideology; developed in Study 1.

Moral Foundation	Medium vs. Low Hesitancy			High vs. Low Hesitancy		
	aOR	95% CI	p-value	aOR	95% CI	p-value
High endorsement of authority	0.92	0.54, 1.56	0.76	0.44	0.27, 0.70	<0.01
Low endorsement of authority	Ref.	-	-	Ref.	-	-
High endorsement of fairness	1.13	0.71, 1.80	0.60	1.09	0.72, 1.66	0.67
Low endorsement of fairness	Ref.	-	-	Ref.	-	-
High endorsement of harm	0.82	0.53, 1.30	0.40	1.10	0.73, 1.66	0.63
Low endorsement of harm	Ref.	-	-	Ref.	-	-
High endorsement of loyalty	1.27	0.77, 2.09	0.36	0.90	0.58, 1.40	0.65
Low endorsement of loyalty	Ref.	-	-	Ref.	-	-
High endorsement of purity	2.12	1.28, 3.52	<0.01*	2.12	1.33, 3.30	<0.01*
Low endorsement of purity	Ref.	-	-	Ref.	-	-
High endorsement of liberty	1.00	0.66, 1.52	0.99	1.96	1.33, 2.89	<0.01*
Low endorsement of liberty	Ref.	-	-	Ref.	-	-

*Statistically significant (p < 0.05)

Supplementary Table 6. Odds ratios, 95% confidence intervals, and p-values for a no-interaction unconditional polytomous logistic regression model; adjusted for age, education, and gender; developed in Study 1.

Moral Foundation	Medium vs. Low Hesitancy			High vs. Low Hesitancy		
	aOR	95% CI	p-value	aOR	95% CI	p-value
High endorsement of authority	0.90	0.53, 1.51	0.68	0.42	0.27, 0.67	<0.01*
Low endorsement of authority	Ref.	-	-	Ref.	-	-
High endorsement of fairness	1.15	0.74, 1.80	0.53	1.01	0.68, 1.51	0.96
Low endorsement of fairness	Ref.	-	-	Ref.	-	-
High endorsement of harm	0.85	0.54, 1.34	0.47	1.01	0.67, 1.52	0.98
Low endorsement of harm	Ref.	-	-	Ref.	-	-
High endorsement of loyalty	1.30	0.79, 2.14	0.30	0.95	0.61, 1.47	0.83
Low endorsement of loyalty	Ref.	-	-	Ref.	-	-
High endorsement of purity	2.08	1.27, 3.40	<0.01*	2.14	1.39, 3.29	<0.01*
Low endorsement of purity	Ref.	-	-	Ref.	-	-
High endorsement of liberty	0.99	0.65, 1.50	0.96	2.24	1.53, 3.28	<0.01*
Low endorsement of liberty	Ref.	-	-	Ref.	-	-

*Statistically significant (p < 0.05)

Supplementary Table 7. Odds ratios, 95% confidence intervals, and p-values for an unconditional polytomous logistic regression model (Model 1B) containing a liberty-age interaction term; adjusted for age and education; developed in Study 1.

Moral Foundation	Medium vs. Low Hesitancy			High vs. Low Hesitancy		
	aOR	95% CI	p-value	aOR	95% CI	p-value
High endorsement of authority	0.86	0.51, 1.46	0.58	0.42	0.26, 0.66	<0.01*
Low endorsement of authority	Ref.	-	-	Ref.	-	-
High endorsement of fairness	1.13	0.72, 1.76	0.60	0.98	0.66, 1.46	0.93
Low endorsement of fairness	Ref.	-	-	Ref.	-	-
High endorsement of harm	0.84	0.54, 1.31	0.44	1.07	0.71, 1.59	0.75
Low endorsement of harm	Ref.	-	-	Ref.	-	-
High endorsement of loyalty	1.34	0.81, 2.20	0.25	0.96	0.62, 1.48	0.85
Low endorsement of loyalty	Ref.	-	-	Ref.	-	-
High endorsement of purity	2.06	1.26, 3.38	<0.01*	2.14	1.39, 3.29	<0.01*
Low endorsement of purity	Ref.	-	-	Ref.	-	-
High endorsement of liberty (18-40 years old)	1.38	0.86, 2.21	0.18	2.48	1.59, 3.87	<0.01*
Low endorsement of liberty (18-40 years old)	Ref.	-	-	Ref.	-	-
High endorsement of liberty (41+ years old)	0.33	0.13, 0.81	0.02*	1.52	0.75, 3.07	0.24
Low endorsement of liberty (41+ years old)	Ref.	-	-	Ref.	-	-

*Statistically significant (p < 0.05)

Supplementary Table 8. Unstandardized beta coefficients, standard errors, and p-values for a multiple linear regression model containing a liberty-age interaction term developed in Study 1. The outcome is Parent Attitudes about Childhood Vaccines short scale scores (0-10). Predictors include moral foundation scores (0-30), education, age (18-50), and an age-liberty interaction.

Predictor	b	SE	p-value
Authority*	-0.158	0.026	<0.0001
Fairness	-0.019	0.025	0.459
Harm	0.004	0.023	0.863
Loyalty	0.015	0.023	0.528
Purity*	0.126	0.017	<0.0001
Liberty*	0.303	0.101	0.003
Age*	0.141	0.059	0.017
Education			
Some college	-0.314	0.319	0.326
College graduate*	-0.873	0.312	0.005
Some graduate school	-0.729	0.450	0.106
Graduate degree*	-1.556	0.363	<0.0001
≤ High school graduate	Ref.	-	-
Liberty*Age	-0.005	0.003	0.077

*Statistically significant ($p < 0.05$).

Supplementary Table 9. Odds ratios, 95% confidence intervals, and p-values for an unconditional polytomous logistic regression model containing a liberty-age interaction term; adjusted for age, education, and political ideology; developed in Study 1.

Moral Foundation	Medium vs. Low Hesitancy			High vs. Low Hesitancy		
	aOR	95% CI	p-value	aOR	95% CI	p-value
High endorsement of authority	0.89	0.52, 1.51	0.67	0.43	0.27, 0.68	<0.01*
Low endorsement of authority	Ref.	-	-	Ref.	-	-
High endorsement of fairness	1.10	0.69, 1.75	0.70	1.10	0.72, 1.68	0.65
Low endorsement of fairness	Ref.	-	-	Ref.	-	-
High endorsement of harm	0.84	0.53, 1.34	0.47	1.05	0.69, 1.59	0.82
Low endorsement of harm	Ref.	-	-	Ref.	-	-
High endorsement of loyalty	1.30	0.79, 2.15	0.31	0.92	0.59, 1.42	0.70
Low endorsement of loyalty	Ref.	-	-	Ref.	-	-
High endorsement of purity	2.10	1.26, 3.51	<0.01*	2.07	1.32, 3.27	<0.01*
Low endorsement of purity	Ref.	-	-	Ref.	-	-
High endorsement of liberty (18-40 years old)	1.37	0.85, 2.21	0.20	2.32	1.63, 4.00	<0.01*
Low endorsement of liberty (18-40 years old)	Ref.	-	-	Ref.	-	-
High endorsement of liberty (41+ years old)	0.33	0.13, 0.81	0.02*	1.30	0.75, 3.07	0.47
Low endorsement of liberty (41+ years old)	Ref.	-	-	Ref.	-	-

*Statistically significant (p < 0.05)

Supplementary Table 10. Odds ratios, 95% confidence intervals, and p-values for an unconditional polytomous logistic regression model containing a liberty-age interaction term; adjusted for age, education, and gender; developed in Study 1.

Moral Foundation	Medium vs. Low Hesitancy			High vs. Low Hesitancy		
	aOR	95% CI	p-value	aOR	95% CI	p-value
High endorsement of authority	0.86	0.51, 1.46	0.58	0.43	0.27, 0.69	<0.01*
Low endorsement of authority	Ref.	-	-	Ref.	-	-
High endorsement of fairness	1.12	0.72, 1.76	0.61	1.00	0.67, 1.49	0.99
Low endorsement of fairness	Ref.	-	-	Ref.	-	-
High endorsement of harm	0.85	0.54, 1.33	0.47	1.00	0.67, 1.52	0.97
Low endorsement of harm	Ref.	-	-	Ref.	-	-
High endorsement of loyalty	1.34	0.81, 2.20	0.25	0.96	0.63, 1.48	0.86
Low endorsement of loyalty	Ref.	-	-	Ref.	-	-
High endorsement of purity	2.07	1.26, 3.39	<0.01*	2.13	1.38, 3.27	<0.01*
Low endorsement of purity	Ref.	-	-	Ref.	-	-
High endorsement of liberty (18-40 years old)	1.37	0.85, 2.21	0.19	2.55	1.63, 4.00	<0.01*
Low endorsement of liberty (18-40 years old)	Ref.	-	-	Ref.	-	-
High endorsement of liberty (41+ years old)	0.33	0.13, 0.81	0.02*	1.52	0.75, 3.07	0.24
Low endorsement of liberty (41+ years old)	Ref.	-	-	Ref.	-	-

*Statistically significant (p < 0.05)

Supplementary Table 11. Unstandardized beta coefficients, standard errors, and p-values from a multiple regression model (Model 2A) testing the association of the six moral values with vaccine attitudes; adjusted for age and education; developed in Study 2.

Predictor	b	SE	p-value
Authority	-0.03	0.02	0.08
Fairness	-0.02	0.02	0.30
Harm	-0.02	0.02	0.34
Loyalty	-0.002	0.02	0.89
Purity	0.06	0.01	<0.01*
Liberty	0.03	0.01	0.01*
Age	0.002	0.01	0.72
Education	-0.06	0.06	0.37

*Statistically significant ($p < .05$)

Supplementary Table 12. Sample items for the Moral Foundations Questionnaire and Liberty Foundations Questionnaire. Questions asked about the relevance of a statement when determining if something was right or wrong (answers ranged from “Not at all relevant” to “Extremely relevant”) and the importance of the presented consideration when making decisions (answers ranged from “Strongly disagree” to “Strongly agree”).

Moral Foundation	Sample relevance item	Sample judgment item
Authority	Whether or not someone conformed to the traditions of society.	If I were a soldier and disagreed with my commanding officer’s orders, I would obey anyway because that is my duty.
Fairness	Whether or not someone acted unfairly.	Justice is the most important requirement for a society.
Harm	Whether or not someone suffered emotionally.	Compassion for those who are suffering is the most crucial virtue.
Loyalty	Whether or not someone did something to betray his or her group.	People should be loyal to their family members, even when they have done something wrong.
Purity	Whether or not someone violated standards of purity and decency.	I would call some acts wrong on the grounds that they are unnatural.
Liberty	Whether or not everyone was free to do as they wanted.	The government interferes far too much in our everyday lives.

Supplementary Table 13. Cronbach's alphas for the established six moral foundation scales (Study 1 and 2), the newly-created vaccine purity-violation beliefs scale (Study 2), the newly-created vaccine liberty-violation beliefs scale (Study 2), and the newly-created vaccine attitudes scale (Study 2).

Survey Scale	Standardized Cronbach's alphas	
	Study 1	Study 2
Authority	0.72	0.72
Fairness	0.68	0.61
Harm	0.72	0.65
Loyalty	0.73	0.75
Purity	0.84	0.85
Liberty	0.71	0.70
Vaccine purity-violation beliefs	N/A	0.88
Vaccine liberty-violation beliefs	N/A	0.91
Vaccine attitudes	N/A	0.91