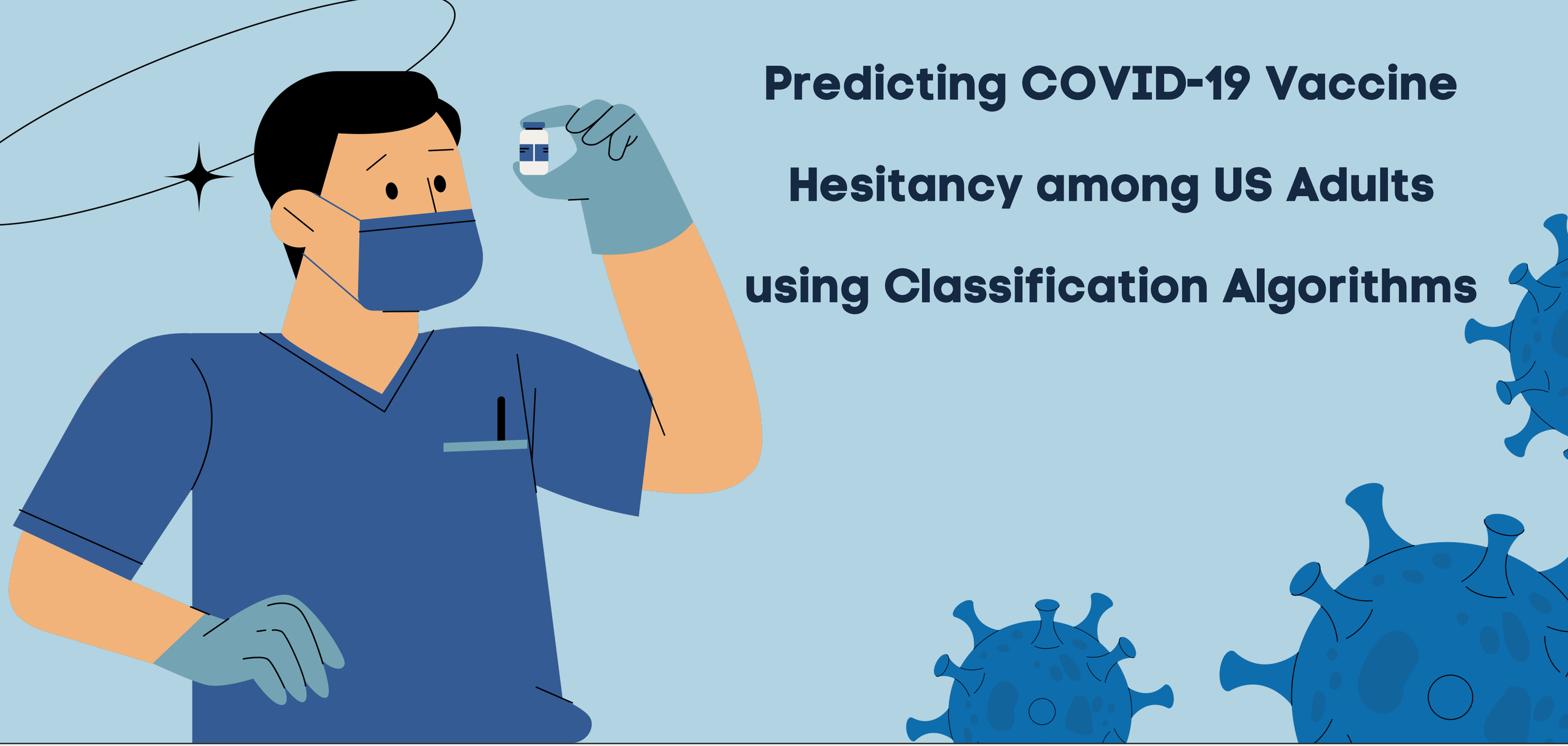


Predicting COVID-19 Vaccine Hesitancy among US Adults using Classification Algorithms

Prasad Bhoite

Date: April 27, 2022

Content Outline

01 Trends in US adult COVID-19 vaccination uptake

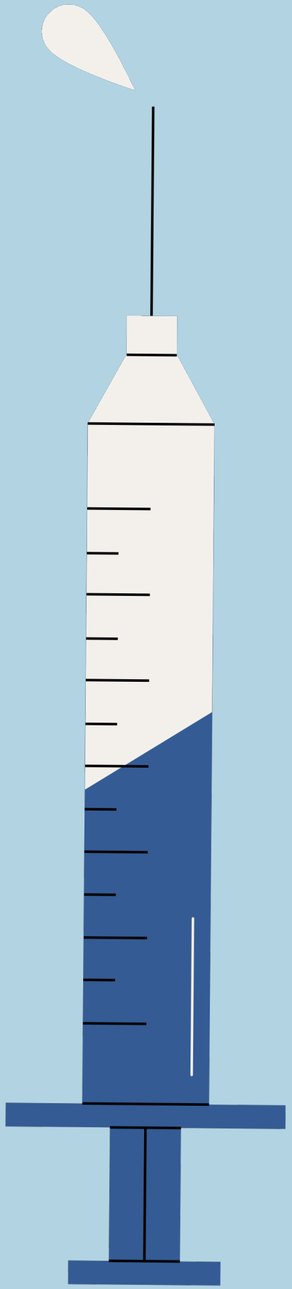
02 Vaccine Hesitancy stratified by Political affiliation

03 Vaccine Hesitancy stratified by Health Literacy

04 Parental Vaccine Hesitancy for self and their Adolescents' Kids

05 COVID-19 Vs HPV: Maternal Vaccine Hesitancy

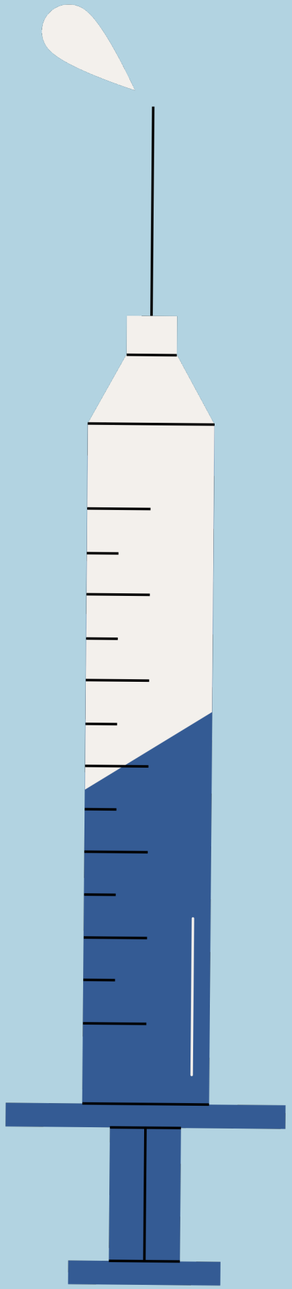
06 Prediction Algorithm, Demonstration and Conclusion



Introduction

Since Beginning of COVID-19 Pandemic in the US:

- 81 million cases
- Almost a million deaths
- Emerging COVID-19 variants and sub-variants



Problem Statement

Vaccine Hesitancy:

- Delay in acceptance or refusal of vaccines

Significant proportion of eligible population is still unvaccinated or boosted

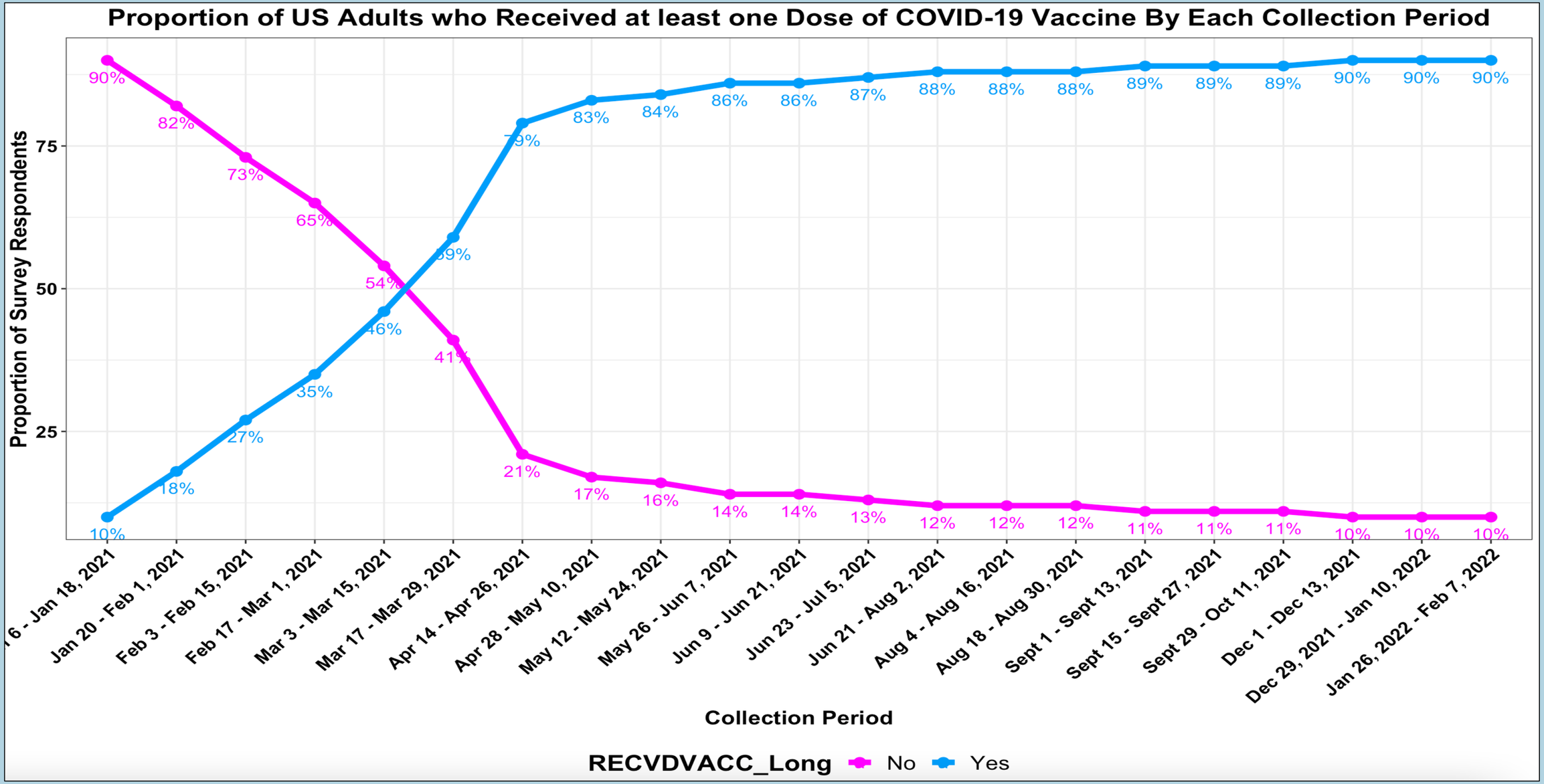
Need to understand vaccine hesitancy factors to develop tools and strategies for vaccine uptake

Datasets

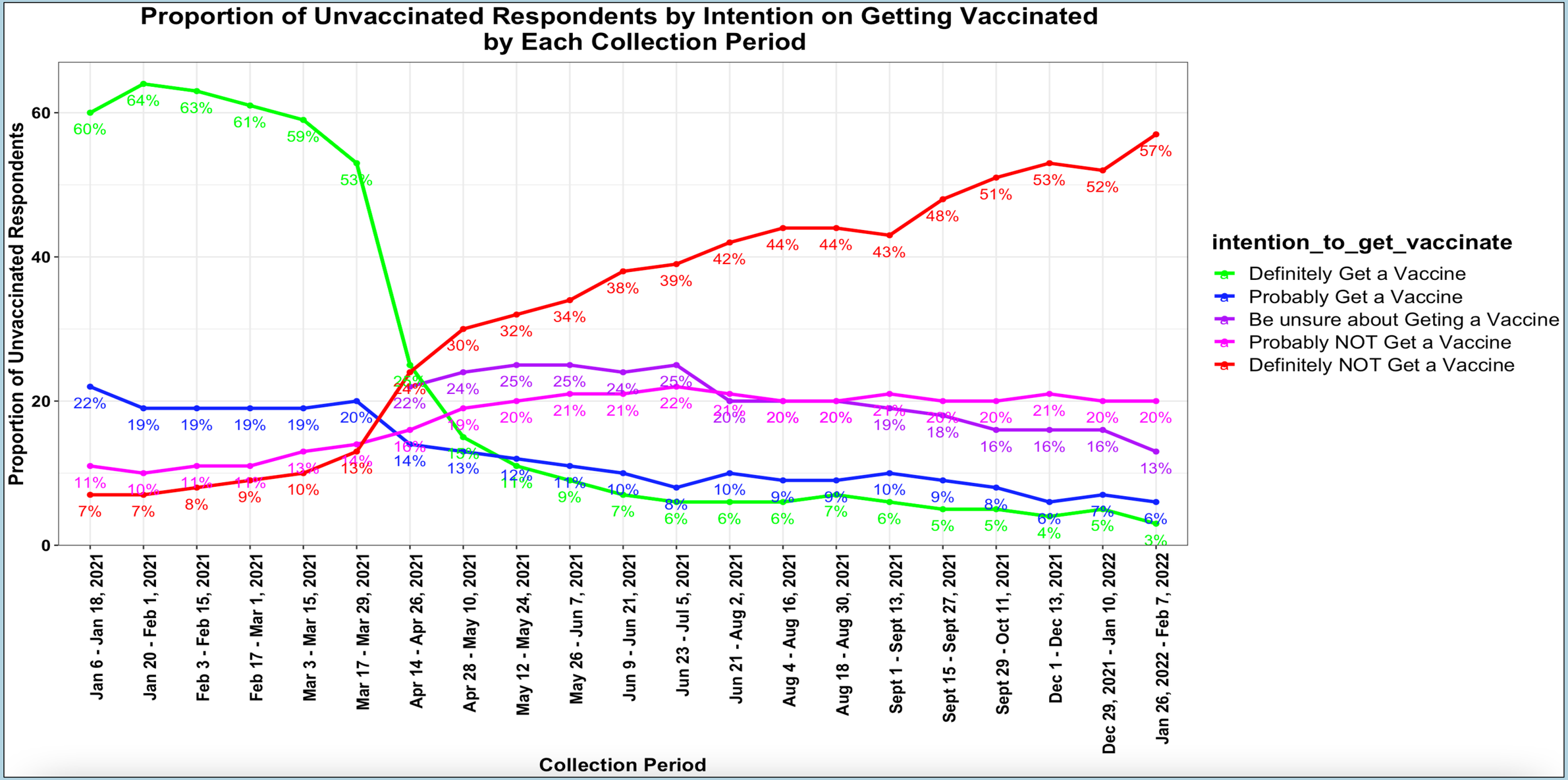
Data Source	Dimension	Important Variables
Household Pulse Survey [U.S. Census Bureau]	1,478,906 X 147	Receipt of vaccine, Intention to get vaccine, Willingness to complete all doses, Reasons for not getting vaccine, Intention to vaccinate children, Socio-demographic Variables
2020 National Immunization Survey- Teen (NIS-Teen) [CDC]	45,008 X 667	Reasons for not getting HPV vaccine, Intention to provide HPV vaccine to adolescent, Socio-demographic Variables
Political Party Affiliation of the Governors	51 X 2	State Name, Political affiliation
National Health Literacy Data	51 X 3	State Name, Estimated mean and median health literacy scores

01 Trends in US adult COVID-19 vaccination uptake

COVID-19 Vaccination Trend among the US adults?

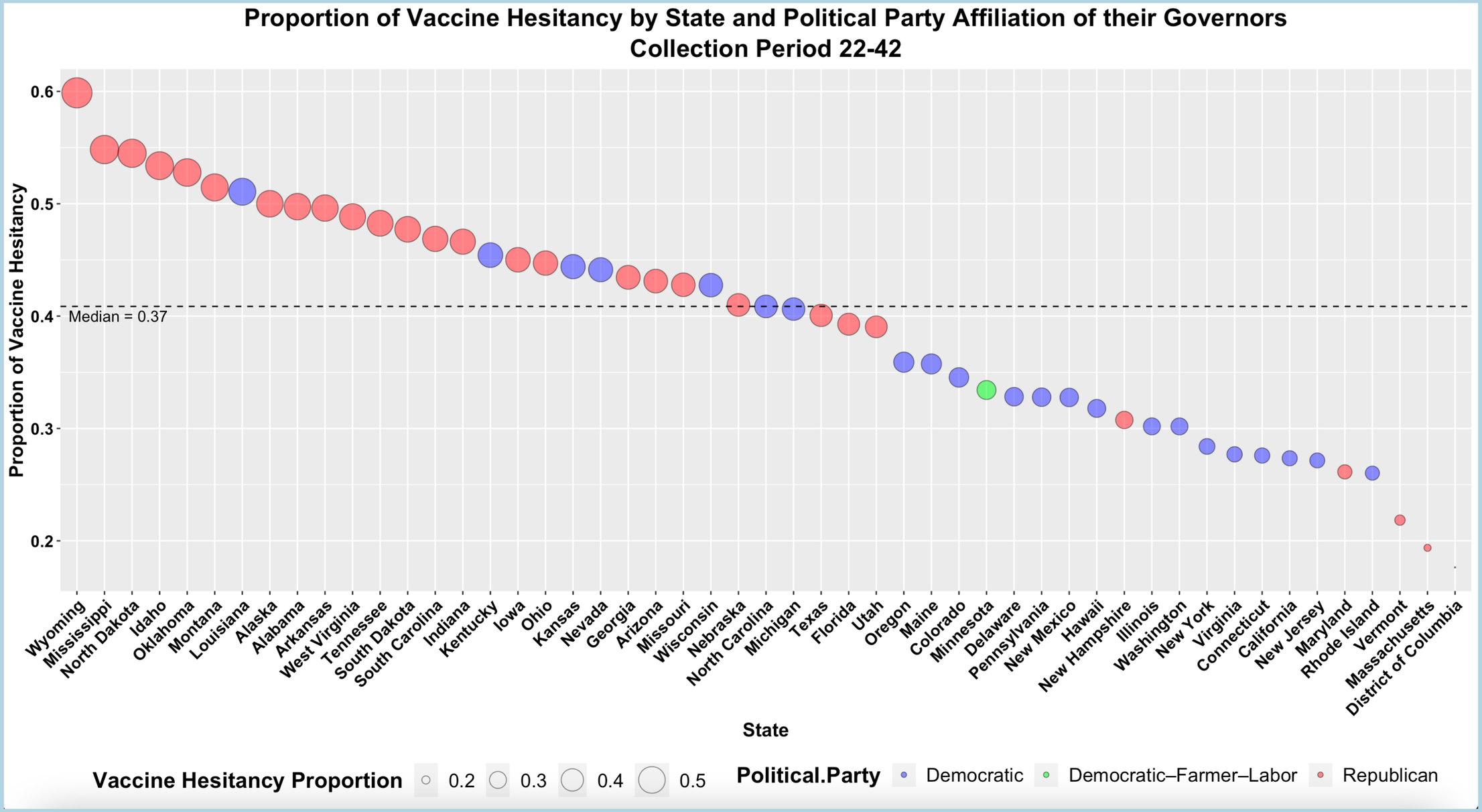


Proportion of Intention to Get Vaccinated among Unvaccinated US Adults



02 Vaccine Hesitancy Stratified by Political affiliation of Governors

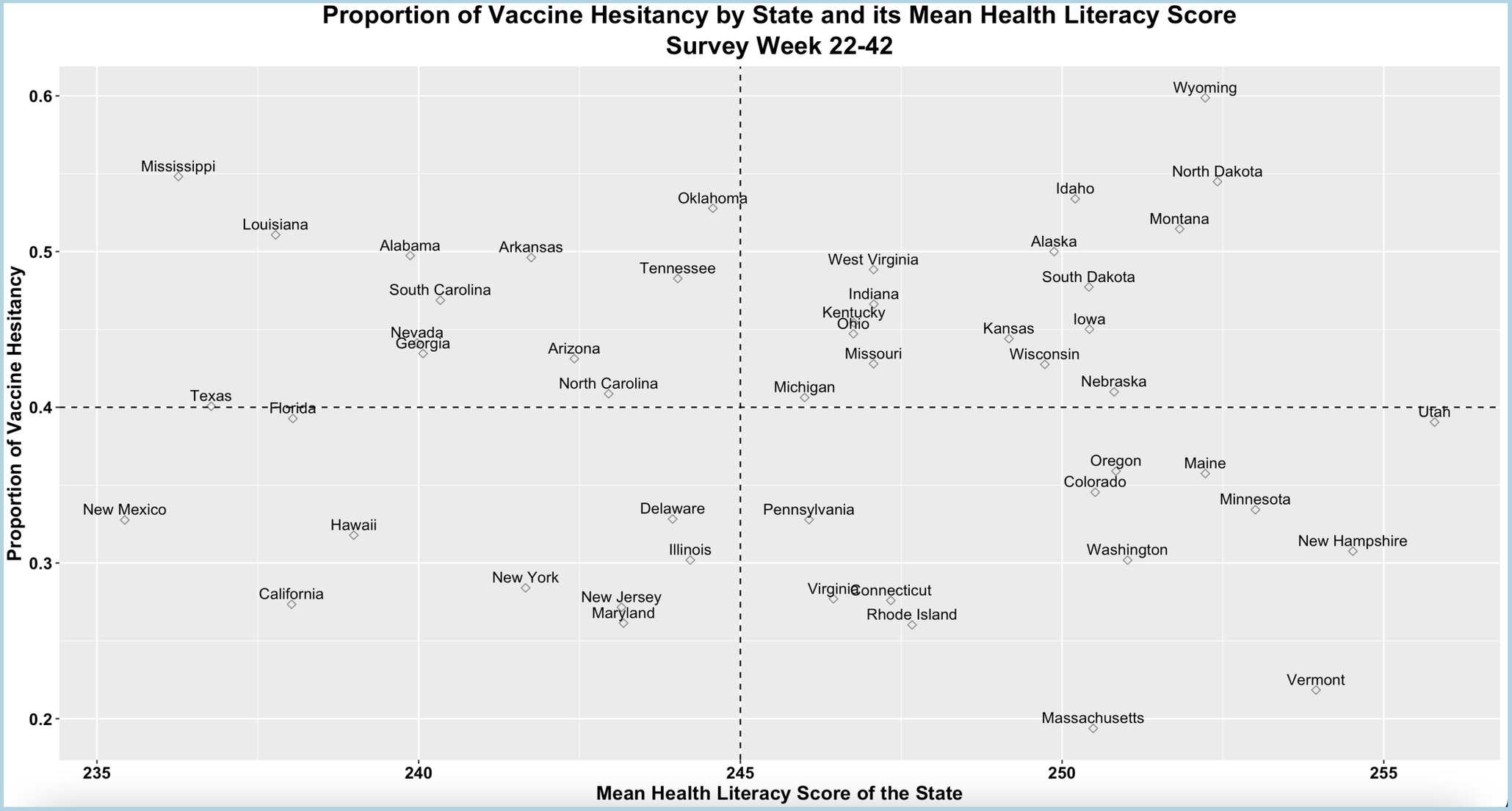
Vaccine Hesitancy by Each State and Political Party Affiliation of the Governors



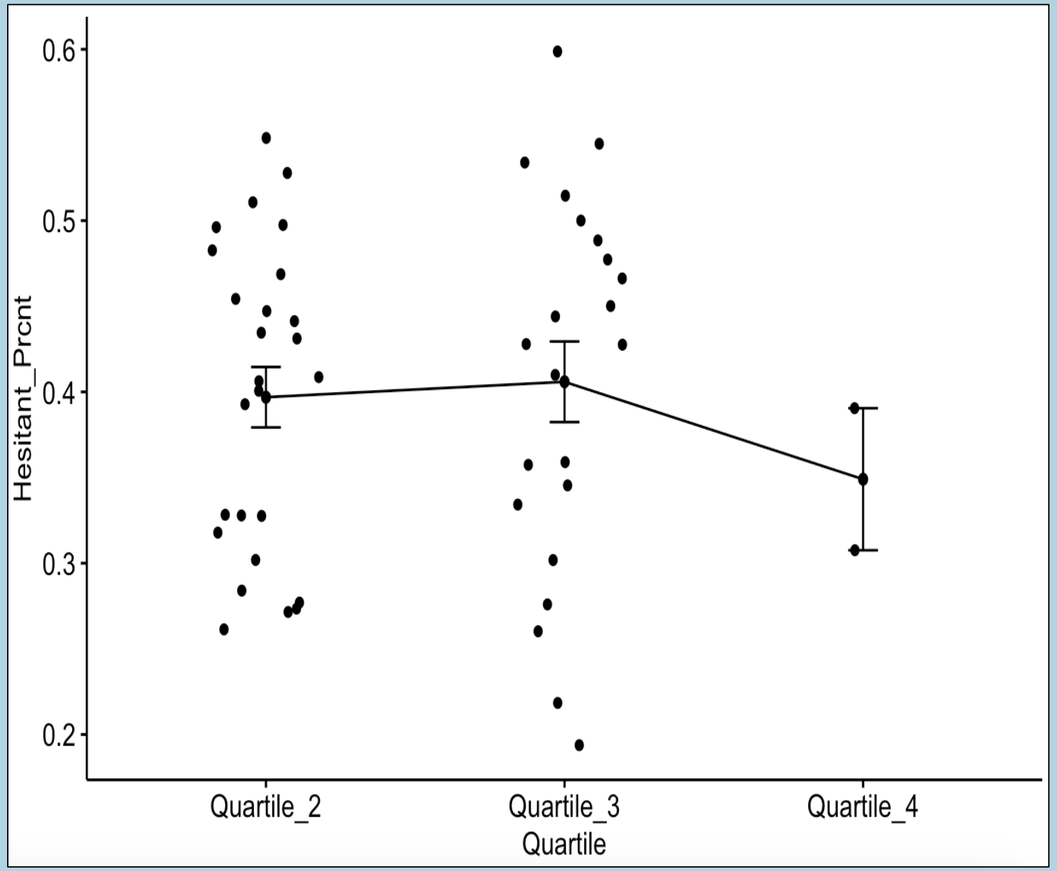
03 Vaccine Hesitancy Stratified by Health Literacy

Vaccine Hesitancy by Each State and Health Literacy

Health Literacy: the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions.



Vaccine Hesitancy by Each State and Health Literacy



Category	Score
Quartile 1 (lowest)	235 or lower
Quartile 2	Higher than 235 to 247
Quartile 2	Higher than 247 to 254
Quartile 4 (highest)	Higher than 254

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
mean_health_literacy_est_cat	2	0.0062	0.003080	0.314	0.732
Residuals	47	0.4615	0.009818		

No Statistically Significant Association

04 Parental Vaccine Hesitancy for Self and their Adolescents' Kids

Adults' Hesitancy to Vaccinate Themselves Vs Children

Demographic Characteristics	Non-Parents' Hesitancy to Vaccinate Themselves	Parents' Hesitancy to Vaccinate Themselves	Parents' Hesitancy to Vaccinate Children Ages 12-17
Overall	**7.00%**	**15.70%**	**24.60%**
Male	7.20%	15.30%	22.90%
Female	6.90%	16.40%	26.10%
Age: 18-24	14.20%	18.00%	25.30%
Age: 25-39	9.50%	26.90%	38.50%
Age: 40-54	11.00%	13.60%	21.40%
Age: 55-64	6.90%	9.60%	18.30%
Age: 65+	3.50%	12.10%	26.30%
White (non-Hispanic)	7.10%	16.60%	26.40%
Black (non-Hispanic)	6.40%	16.20%	24.40%
Asian (non-Hispanic)	**1.90%**	3.10%	6.10%
Other/Multiple Race	11.70%	20.90%	30.60%
Hispanic	7.60%	14.50%	22.00%
No College Degree	11.10%	22.30%	33.20%
College Degree or Higher	4.80%	12.80%	19.50%

Factors Associated with Parents' Hesitancy to Vaccinate their Children (12-17 yr)

Odds Ratios: Factors Associated with Parents' Hesitancy to Vaccinate Children Ages 12-17		
Demographic Characteristics		**Hesitant**
Gender	**Male**	Ref.
	Female	0.17***
Age Category	**Age: 18-24**	Ref.
	Age: 25-39	0.61***
	Age: 40-54	-0.21***
	Age: 55-64	-0.4***
	Age: 65+	0.05***
Race-Ethnicity	**White (non-Hispanic)**	1.70***
	Black (non-Hispanic)	1.59***
	Asian (non-Hispanic)	Ref.
	Other/Multiple Race	1.91***
	Hispanic	1.46***
Education	**No College Degree**	Ref.
	College Degree or Higher	-0.72***

05 COVID-19 Vs HPV: Maternal Vaccine Hesitancy

Maternal Hesitancy to Vaccinate their adolescents: COVID-19 Vs HPV Vaccine

Parental Hesitancy to Vaccinate their Adolescents: COVID-19 Vaccine Vs HPV Vaccine			
Demographic Characteristics		**COVID-19 Vaccine (12-17 Years)**	**HPV Vaccine (13-17 Years)**
Gender	**Female**	**77.3%**	**55.0%**
Age Category	**Age: <=34 Years**	77.2%	48.8%
	Age: 35-44 Years	75.7%	54.5%
	Age: >= 45 Years	78.7%	56.6%
Race-Ethnicity	**White (non-Hispanic)**	82.1%%	59.5%
	Black (non-Hispanic)	64.5%%	50.0%
	Non-Hispanic Other + Multiple Race	75.4%%	56.5%
	Hispanic	68.5%%	44.3%
Education	**No College Degree**	76.5%	53.9%
	College Degree or Higher	78.2%	56.4%

06 Prediction Algorithm, Demonstration & Conclusion

Machine Learning Model Building: Feature Engineering

Model Building: Feature Engineering

- Dealing with Missing Values
- Class imbalance

Before:

```
Target_Var                    1533
HH_Income_2020              105472
Gender                           0
Age_Category                     0
Educational_Attainment           0
hisp_rrace                       0
state_name                       0
Marital_Status                2567
HH_w_Minors_Vs_AdultOnly         0
dtype: int64
```

After: Removing Missing Values

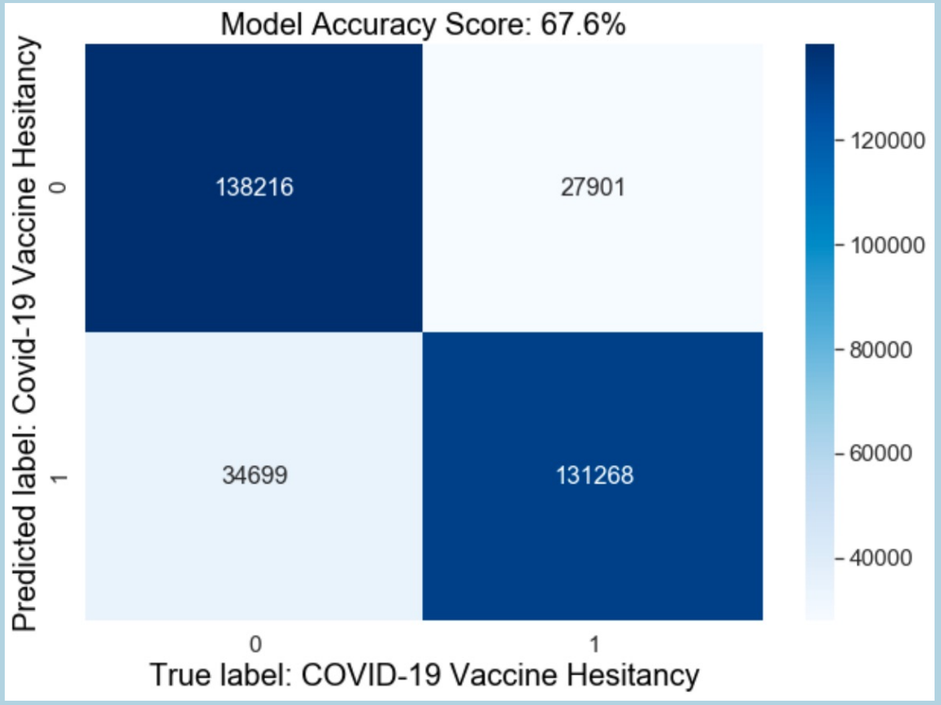
```
Target_Var                    0
HH_Income_2020                0
Gender                        0
Age_Category                  0
Educational_Attainment        0
hisp_rrace                    0
state_name                    0
Marital_Status                0
HH_w_Minors_Vs_AdultOnly      0
dtype: int64
```

Machine Learning Model Building: Training, Testing and Evaluation

Model Performance:
After Hyperparameter Tuning

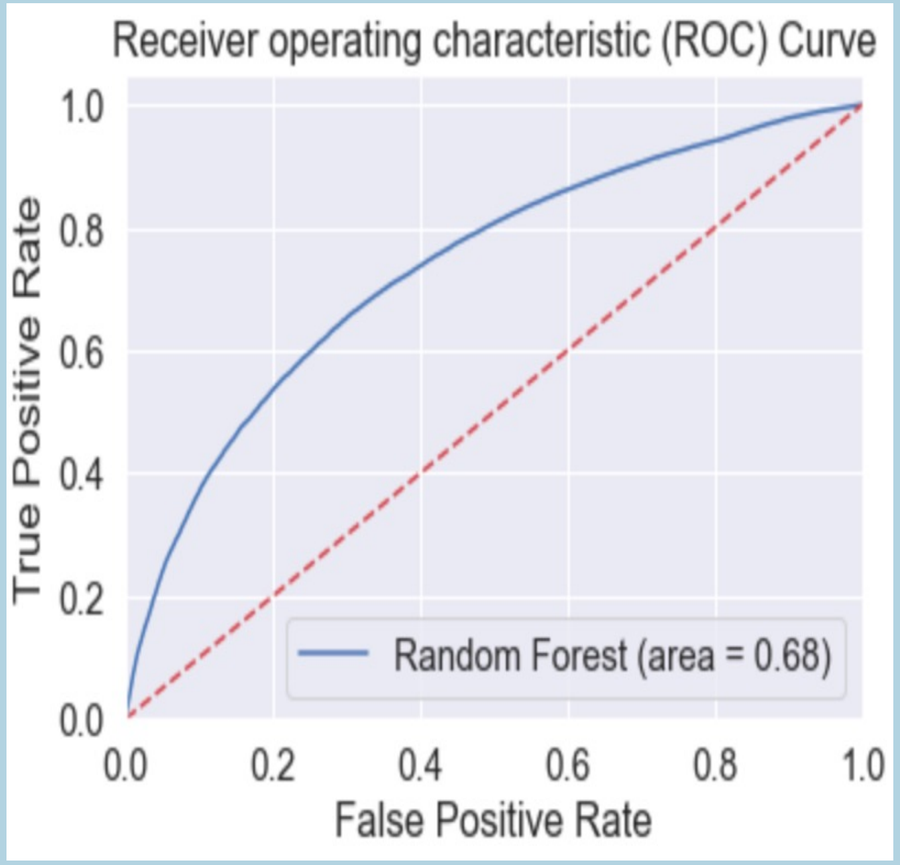
	Model	Accuracy	Precision	Recall	F-1 Score	Training Time	Prediction Time
0	NB	0.595	0.595	0.600	0.597	0.068	0.005
1	LR	0.603	0.603	0.604	0.604	0.988	0.003
2	DT	0.672	0.698	0.608	0.650	0.744	0.032
3	RF	0.676	0.687	0.649	0.668	25.866	2.728
4	GBT	0.660	0.663	0.656	0.659	18.507	0.237
5	EXT	0.675	0.699	0.616	0.655	2.178	0.366
6	ADB	0.655	0.663	0.636	0.649	14.599	0.754

Confusion Matrix
Best Model: Random Forest

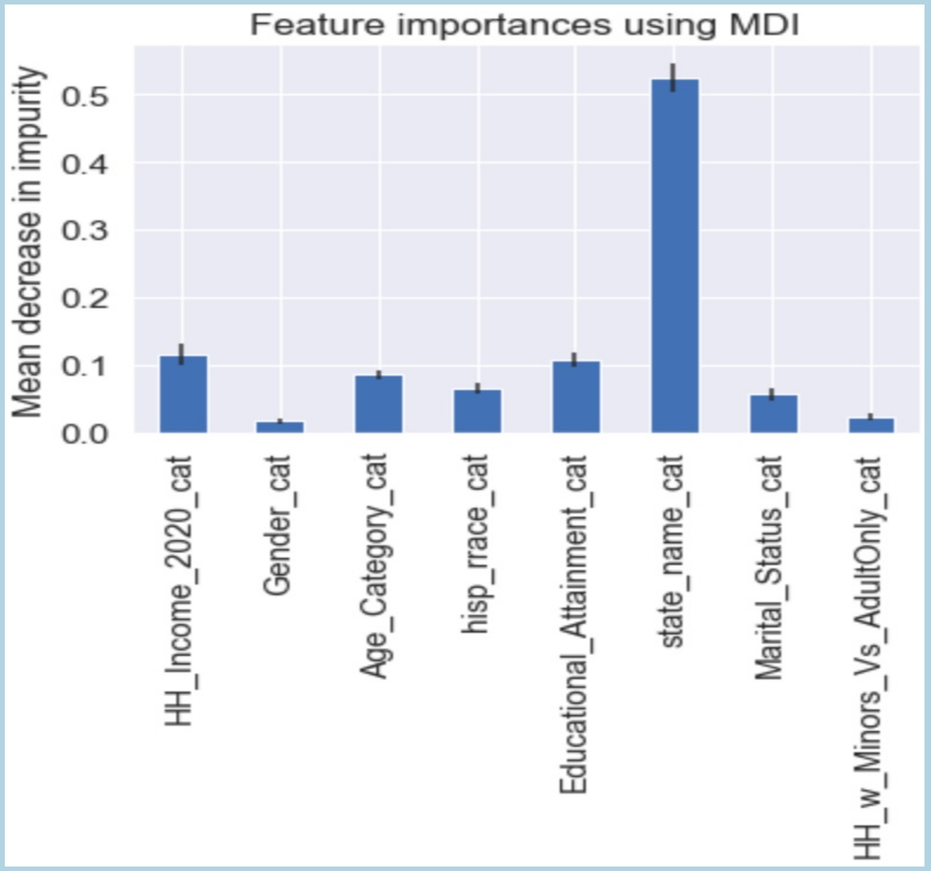


Machine Learning Model Building: Evaluation

Model Performance:
After Hyperparameter Tuning



Feature Importance
Best Model: Random Forest

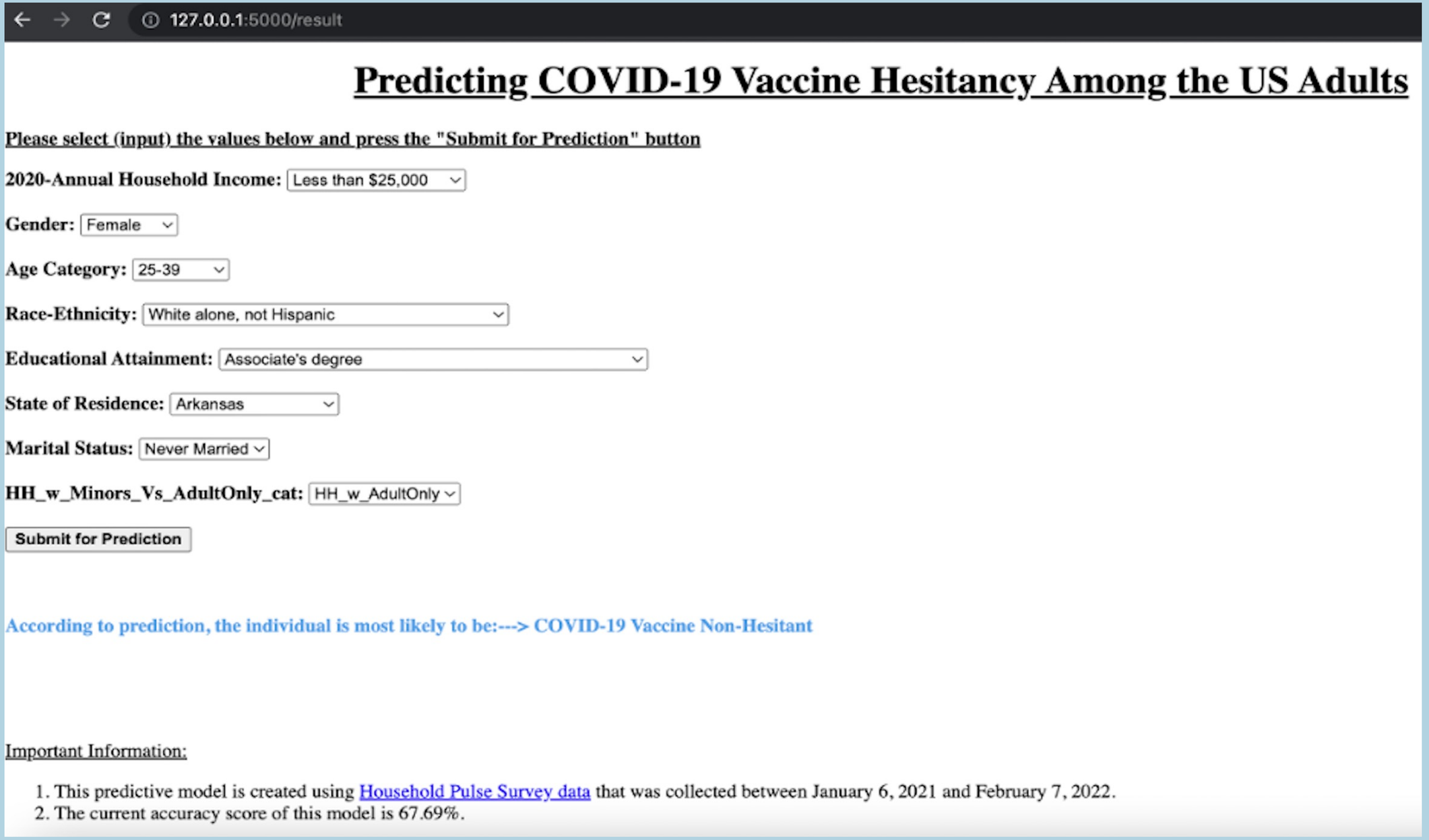


Conclusion

- COVID-19 vaccine hesitancy may be more related to ideological and personal beliefs than knowledge.
- Similarities in maternal Sociodemographic and reasons for vaccine hesitancy for COVID-19 and HPV vaccine.
- Addressing COVID-19 vaccine hesitancy requires customized approaches tailored to address different groups.
- This Machine Learning instrument could support State and Local outreach interventions by enabling the anticipation of personal needs, and pre-planning interventions.
- Limitations:
  - Sample might not be representative
  - Aggregated Health Literacy Data
  - Low model accuracy

Demonstration

Web API of Model created using Flask and Python



Questions?

Thank you!