MACHINE LEARNING MODELS TO PREDICT COVID-19 VACCINATION INTENTION: AN INDIAN STUDY

Vivek Raj S N [A], Manivannan S K [B]

ARTICLE INFO	ABSTRACT
  	Purpose: Covid 19 pandemic has taken the world by shock for last few years, and it has greatly impacted the livelihood of people across all walks of life and even the economies of many nations got greatly affected. Governments across the globe revived from the impact of covid-19 pandemic using many strategies and policies which were formulated under the guidance of the world health organization. One of the Prime weapons which helped the governments and public against covid -19 is vaccination. This research which was conducted August 2021 was done to understand the perception of the public towards the covid 19 vaccination and to predict the public intention to take up covid -19 vaccination using the health belief model constructs. **Theoretical framework:** The Study has used the variables of the health belief model namely the perceived severity, perceived susceptibility, Perceived Benefits, Cues to action and other socio-demographic variables to predict the intent of the respondents towards taking Covid-19 vaccination. **Design/methodology/approach:** Data was collected using a self-administered online questionnaire distributed to the respondents from Tamil Nadu, India who are above 18 years of age. Machine Learning Algorithms like Logistic Regression, Artificial Neural Networks were used to predict the public intent to take up covid 19 vaccination. **Findings**: From the Analysis of Logistic Regression and Artificial Neural Network, it was found that Health Belief Model Constructs Perceived Barriers, Perceived Benefits and Cues to action, were significant factors that affect the public intention to vaccinate. **Research, Practical & Social implications:** Findings of the research will help the government, stake holders to understand the factors impacting the respondent's intent to covid-19 vaccination which will guide them to plan better strategies for future vaccination drives **Originality/value:** The Study has used to two different machine learning algorithms to compare and corroborate the research findings and in turn identifying the significant predictors of covid-19 vaccination intent Doi: https://doi.org/10.26668/businessreview/2022.v7i6.e977

[A] *Research Scholar, College of Management, SRM Institute of Science and Technology, Kattankulathar, Chengalpattu, Tamilnadu, India. E-mail: vn3984@srmist.edu.in Orcid: https://orcid.org/0000-0002-7583-8620*
[B] *Associate Professor, College of Management, SRM Institute of Science and Technology, Kattankulathar, Chengalpattu, Tamilnadu, India. E-mail: manivans@srmist.edu.in*
Orcid: https://orcid.org/0000-0002-4923-7864

MODELOS DE APRENDIZAGEM DE MÁQUINAS PARA PREVER A INTENÇÃO DE VACINAÇÃO COVID-19: UM ESTUDO INDIANO

RESUMO

Objetivo: A pandemia da Covid 19 tem tomado o mundo pelo choque nos últimos anos, e tem impactado grandemente o sustento das pessoas em todos os estilos de vida e até mesmo as economias de muitas nações foram grandemente afetadas. Governos de todo o mundo ressuscitaram do impacto da pandemia da covida 19 usando muitas estratégias e políticas que foram formuladas sob a orientação da organização mundial de saúde. Uma das principais armas que ajudou os governos e o público contra a covid-19 é a vacinação. Esta pesquisa, realizada em agosto de 2021, foi feita para compreender a percepção do público em relação à vacinação contra a covida 19 e para prever a intenção pública de adotar a vacinação contra a covida -19 usando as construções do modelo de crença na saúde.

Estrutura teórica: O Estudo utilizou as variáveis do modelo de crença em saúde, ou seja, a percepção da gravidade, a percepção da suscetibilidade, os Benefícios Percebidos, os Tacos de Ação e outras variáveis sociodemográficas para prever a intenção dos entrevistados de tomar a vacina Covid-19.

Desenho/método/abordagem: Os dados foram coletados usando um questionário online auto-administrado distribuído aos respondentes de Tamil Nadu, Índia, acima de 18 anos de idade. Algoritmos de aprendizado de máquinas como Regressão Logística, Redes Neurais Artificiais foram usados para prever a intenção pública de tomar a vacina Covid 19.

Descobertas: Da Análise de Regressão Logística e Rede Neural Artificial, descobriu-se que o Modelo de Crença em Saúde Constrói Barreiras Percebidas, Benefícios Percebidos e Tacos para Ação, foram fatores significativos que afetam a intenção pública de vacinar.

Pesquisa, implicações práticas e sociais: As descobertas da pesquisa ajudarão o governo, os interessados a compreender os fatores que afetam a intenção do entrevistado de vacinar-19, o que os orientará a planejar melhores estratégias para futuras campanhas de vacinação.

Originalidade/valor: O estudo utilizou dois algoritmos diferentes de aprendizagem de máquinas para comparar e corroborar os resultados da pesquisa e, por sua vez, identificar os preditores significativos da intenção de vacinação covid-19

Palavras-chave: Aprendizagem de Máquina, Modelo de Crença em Saúde, Análise Sentimental, Regressão Logística, Covid-19, Vacina, Rede Neural Artificial.

MODELOS DE APRENDIZAJE AUTOMÁTICO PARA PREDECIR LA INTENCIÓN DE VACUNACIÓN CONTRA COVID-19: UN ESTUDIO INDIO

RESUMEN

Propósito: La pandemia de Covid 19 ha conmocionado al mundo en los últimos años y ha afectado enormemente a los medios de subsistencia de personas de todas las profesiones y condiciones, e incluso a las economías de muchas naciones. Los gobiernos de todo el mundo se han recuperado del impacto de la pandemia de Covid-19 utilizando muchas estrategias y políticas formuladas bajo la dirección de la Organización Mundial de la Salud. Una de las principales armas que ayudaron a los gobiernos y al público contra el covid-19 fue la vacunación. Esta investigación, realizada en agosto de 2021, se llevó a cabo para comprender la percepción del público sobre la vacunación contra el covid 19 y predecir la intención del público de vacunarse contra el covid 19 utilizando los constructos del modelo de creencias sobre la salud.

Marco teórico: El estudio ha utilizado las variables del modelo de creencias sobre la salud, a saber, la gravedad percibida, la susceptibilidad percibida, los beneficios percibidos, las claves para la acción y otras variables sociodemográficas para predecir la intención de los encuestados de vacunarse contra el Covid-19.

Diseño/metodología/enfoque: Los datos se recopilaron mediante un cuestionario autoadministrado en línea distribuido a los encuestados de Tamil Nadu, India, mayores de 18 años. Se utilizaron algoritmos de aprendizaje automático como la regresión logística y las redes neuronales artificiales para predecir la intención del público de vacunarse contra el Covid 19.

Resultados: A partir del análisis de regresión logística y de redes neuronales artificiales, se descubrió que los constructos del modelo de creencias sobre la salud -barreras percibidas, beneficios percibidos y claves para la acción- eran factores significativos que afectaban a la intención del público de vacunarse.

Investigación, implicaciones prácticas y sociales: Los resultados de la investigación ayudarán al gobierno y a las partes interesadas a comprender los factores que influyen en la intención de vacunación de los encuestados, lo que les servirá de guía para planificar mejores estrategias para futuras campañas de vacunación.

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Originalidad/valor: El estudio ha utilizado dos algoritmos diferentes de aprendizaje automático para comparar y corroborar los resultados de la investigación y, a su vez, identificar los predictores significativos de la intención de vacunación contra el Covid-19.

Palabras clave: Aprendizaje Automático, Modelo de Creencias en Salud, Análisis Sentimental, Regresión Logística, Covid-19, Vacuna, Red Neuronal Artificial.

INTRODUCTION

Covid-19 Virus (SARS-CoV-2) was first discovered in China had its hold in more than 125 nations killing more than 1,000,000 people (Gupta et al., 2020). Covid -19 Pandemic had a severe effect on the livelihood of the customers, workers, Financial Market places and economy as a whole (Açikgöz & Günay, 2020)(Gupta et al., 2020) and it had an tremendous impact on the Global Supply chain(Açikgöz & Günay, 2020) such as its effect on China's pharmaceutical industry which caused the global surge in price of life saving drugs owing to deficit of raw material shortage(Gupta et al., 2020). Covid-19 has not only impacted the health systems of countries, but economies were also severely impacted. It has impacted the livelihood of many people of various strata in both developing and developed countries. Many people lost their jobs due to layoffs and many businesses were closed. Countries slowly recovered from this impact using policies like Lock Down , Self-Distancing ,Mask Mandate, increase in quantum of testing and avoiding large meetings.(Gautam & Hens, 2020). Employees were asked to work from home and Companies operated in virtual model. Even Educational system in India and elsewhere were forced to halt for an interim period. First Wave of Covid-19 began by September 2020 in India and by March 2021, Covid19 -Second Wave took Indian health care by storm , overpowering both public and private health facilities (Ganesan, 2022) . In this Background Cowin Platform was launched by Government of India on 16th January 2021 as a cloud platform to manage, disseminate, implement and asses covid-19 vaccinations (Ganesan, 2022). Government of India with its digital approach was able to successfully vaccinate the world largest democracy and in July 2021 , Indian Prime Minister announced that Cowin Platform as open source and it will be accessible for any of the countries ("CoWin Platform Made Open Source," 2021) and by July 2022 , India was able to achieve a key landmark as it crossed 200 crore vaccine doses("India Crosses 200-Crore Covid-19 Vaccine Doses Mark," 2022) . One of the key achievement of India in this battle against covid-19 pandemic is production of its native made vaccine , covaxin which was produced by Bharath Biotech (Chakraborty et al., 2021) and currently India has a total Vaccination Count of 2,18,99,72,644 on October 10th 2022 , 08.00 IST (MoHFW | Home, n.d.). This Study is important because the

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research explores the intention of the public towards covid 19 vaccination post second wave in India i.e., during August 2021. The study uses a proven health belief model to identify the significant features of the model which will impact the respondent's decision to take up covid 19 vaccination. This will help the policy makers and other relevant stakeholders to frame strategies, policies, and communication in case of a future vaccine campaign or a pandemic situation if the need arises. The Article is segmented into the following chapters. Chapter 2 deals with literature review covering the prior significant research works contributing to our research objectives. Chapter 3 presents the details about the research methodology where we discuss the research design, sampling, and the research objectives. Chapter 4 deals with the data analysis where the focus moves towards the use of machine learning algorithms for predicting the public intent to take up vaccination. Further in Chapter 5 findings and suggestions were presented followed by chapter 6 and chapter 7 where the limitations and conclusion were discussed. References were listed in chapter 8.

LITERATURE REVIEW

Vaccination is one of the keenly researched streams owing to the multidisciplinary nature of the study and its key role in combating covid-19 or any such future pandemic in case the need arises. There are various studies which have been done in the recent past to study the covid-19 vaccination intention. The Studies were conducted in countries with different geo-political differences such as the united states (Latkin et al., 2021; Malik et al., 2020; Mercadante & Law, 2021) , India (Goruntla et al., 2021) , Bangladesh (Kabir et al., 2021), Iran (Fathian-Dastgerdi et al., 2021), Italy(Caserotti et al., 2021), Low and Middle Income Countries (Bono et al., 2021), Malaysia (Wong et al., 2020),Russia(Tran et al., 2021), Saudi Arabia (Alobaidi, 2021), Sri Lanka(Mahindarathne, 2021) , United Kingdom (Paul et al., 2021). Significant Research works were carried out to study the factors affecting the respondents intent to take up vaccination and acceptance of vaccination by the respondents (Alobaidi, 2021; Askarian et al., 2020; Bono et al., 2021; Caserotti et al., 2021; Goruntla et al., 2021; Kabir et al., 2021; Latkin et al., 2021; Malik et al., 2020; Mercadante & Law, 2021, 2021; Patwary et al., 2021; Paul et al., 2021; Tran et al., 2021; Wong et al., 2020) and there are some studies which are keen on studying the respondents willingness to pay for the vaccination (Goruntla et al., 2021; Kabir et al., 2021; Wong et al., 2020) which is a key area since free vaccination programs may not be required for all sections of population and it will help the policy makers to identify the right population for free and paid vaccination campaigns. Most of the Studies in the literature have used logistic regression to predict the vaccination intent of the respondents since the dependent

variable i.e., vaccination intention which is categorical (Patwary et al., 2021; Askarian et al., 2020; Wong et al., 2020; Kabir et al., 2021; Paul et al., 2021; Goruntla et al., 2021; Alobaidi, 2021; Tran et al., 2021; Malik et al., 2020). There are some studies which have used other techniques like regression (Mahindarathne, 2021), one way Anova and Path Analysis (Mercadante & Law, 2021) . Majority of the Previous studies have used health belief model to explain the covid-19 vaccine intention related health behaviors of the respondents(Askarian et al., 2020; Fathian-Dastgerdi et al., 2021; Goruntla et al., 2021; Kabir et al., 2021; Mahindarathne, 2021; Mercadante & Law, 2021; Patwary et al., 2021; Tran et al., 2021; Wong et al., 2020) while a significant study has integrated both health belief model and theory of planned behavior(Patwary et al., 2021). The current research has employed predictors of the health belief model to predict the covid-19 vaccination intention , there are also other studies which have used health belief model predictors to predict other health related behaviors such as the customers intention to use online food delivery (Mehrolia et al., 2021) , covid-19 preventive behavior (Fathian-Dastgerdi et al., 2021; Mahindarathne, 2021).

From the literature review it is understood that majority of the studies have used the variables of the health belief model to predict the respondent's intent to take up covid-19 vaccination. Our study is in line with the other studies by employing the health belief model. Most of the models have used Logistic regression to identify the significant factors affecting the respondent's vaccination intent, our research study differs here as it has employed two different machine learning algorithms Binary Logistic Regression and Artificial Neural Networks to identify the significant variables impacting the respondent's intent to take up covid-19 vaccination.

METHODOLOGY

This research involves the collection of data using an online self-administered questionnaire using google forms. The target population for study is the general population of Tamil Nadu, India who are above eighteen years of age and eligible for covid vaccination at the time of data collection i.e., during August 2021. A total of 412 respondents participated in the survey which was collected using the non-probability convenience sampling methodology. The Sample size is deemed to be sufficient as the per the scientific evidences put forward by the significant previous research findings (Hair, 2014; Memon et al., 2020). The Study is based on the Health Belief Model which is one of the most used models to understand the health-related behaviors of the respondents.

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The predictor variables are derived from the Health Belief Model which states that a person's health associated behavior depends on a person's belief (Mehrolia et al., 2021). The Following Variables proposed by Health Belief Model have been used as predictor variables for the machine learning algorithms.

Perceived susceptibility(Alobaidi, 2021; Askarian et al., 2020; Fathian-Dastgerdi et al., 2021; Goruntla et al., 2021; Kabir et al., 2021; Patwary et al., 2021; Wong et al., 2020) – This Predictor describes an individual's belief regarding the odds of obtaining an infection or disease .In our research it denotes the respondents belief regarding the risk of getting covid-19 infection

Perceived Benefits(Alobaidi, 2021; Askarian et al., 2020; Fathian-Dastgerdi et al., 2021; Goruntla et al., 2021; Kabir et al., 2021; Mercadante & Law, 2021; Patwary et al., 2021; Tran et al., 2021; Wong et al., 2020) – This Predictor describes a person's perception regarding effectiveness of one health related action which will substantially reduce the risk of contracting a disease . In this research it denotes the respondent's perception regarding the benefits of covid-19 vaccination in reducing the risks of getting the covid-19 infection.

Perceived Barriers(Alobaidi, 2021; Askarian et al., 2020; Fathian-Dastgerdi et al., 2021; Goruntla et al., 2021; Kabir et al., 2021; Mercadante & Law, 2021; Patwary et al., 2021; Tran et al., 2021; Wong et al., 2020) – This Predictor denotes the individual's belief on various obstacles or impediments to perform a health-related behavior. Here in this research, it denotes the respondent's belief regarding the barriers for getting a covid-19 vaccination.

Cues to Action(Alobaidi, 2021; Goruntla et al., 2021; Kabir et al., 2021; Mercadante & Law, 2021; Patwary et al., 2021; Wong et al., 2020) - This Predictor denotes the stimulus or cues (both internal and external) required to trigger health related decision-making process . In this research work it denotes the cues or trigger points that stimulate the respondent's decision to take up covid-19 vaccination.

Perceived Severity(Alobaidi, 2021; Askarian et al., 2020; Fathian-Dastgerdi et al., 2021; Goruntla et al., 2021; Kabir et al., 2021; Patwary et al., 2021; Wong et al., 2020) - This predictor denotes a person's belief regarding seriousness of an infection and in this case, it denotes the respondent's perception regarding severity of covid-19 infection.

The Research Study employs two popular machine learning algorithms Logistic Regression and Artificial Neural Networks by using the variables of health belief model, socio-demographic variables as predictors as provided in Table 1 to predict the respondents intent to take up covid-19 vaccination.

RESULTS

The Research Study uses two popular machine learning algorithms like logistic regression and Artificial Neural Networks to identify the significant features of Health Belief Model which impacts the respondent's intention to vaccinate. The Study also uses the demographic variables as predictors along with the health belief model constructs. Table 1 provides the list of socio-demographic variables which were used as predictors along with the HBM Constructs.

TABLE 1 - SOCIO- DEMOGRAPHIC VARIABLES

S. No	Features	Scale
1	Age	Continuous
2	Gender	Categorical
3	Marital Status	Categorical
4	Locality	Categorical
5	Education	Categorical
6	Monthly Income	Categorical
7	Chronic Health Conditions	Dichotomous
8	Have you been affected by Covid before?	Dichotomous
9	Has anyone close to you been directly impacted by the COVID-19?	Dichotomous

Source: Prepared by the authors (2022)

Before Proceeding to Machine Learning Analysis, Cronbach Alpha's test was conducted to assess the internal consistency of the Health Belief Model Constructs. Cronbach Alpha Values are Perceived benefits(0.82) , perceived severity(0.70) ,Perceived susceptibility(0.74), Perceived barriers(0.77) ,Cues to action(0.85) and the Alpha Values are in the range of 0.70 to 0.85 which are acceptable indicators of internal consistency (Daud et al., 2018; Mahindarathne, 2021; Nunnally & Bernstein, 1994; Pallant, 2020) . Next VIF values are assessed to test the muti collinearity between the independent constructs and VIF values are in the range of 1.34 to 2.00 which are much below the acceptable value of 10(Mahindarathne, 2021) and hence we can conclude that there is absence of multicollinearity.

TABLE 2- RELIABILITY AND VALIDITY

	CR (Composite Reliability)	Cronbach's alpha	AVE (Average Variance Extracted)	VIF
Perceived susceptibility	0.85	0.74	0.66	1.34
Perceived Severity	0.81	0.70	0.59	1.66
Perceived Benefits	0.89	0.82	0.74	1.39
Perceived Barriers	0.85	0.77	0.52	1.31
Cues to Action	0.89	0.85	0.57	2.00

Source: Prepared by the authors (2022)

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Table 2 provides the details regarding the reliability and validity of the Health Belief Model constructs. For establishing convergent validity, the following conditions must be met, Cronbach Alpha values must be greater than or equal to 0.6(Ayedh et al., 2021), AVE values muse be 0.5 or greater (Ayedh et al., 2021), Composite Reliability must be greater or equal to 0.7(Mehrolia et al., 2021). Since all the values of Alpha, CR and AVE as given in Table 2. are greater than recommended values, convergent validity is established.

Discriminant Validity is measured through HTMT ratios as given in the Table 3 , Since HTMT correlation ratio is less than 0.95 as prescribed by (Henseler et al., 2015) , Discriminant Validity of the constructs are established.

TABLE 3 -HTMT RATIOS

	Perceived susceptibility	Perceived Severity	Perceived Benefits	Perceived Barriers
Perceived Severity	0.654			
Perceived Benefits	0.303	0.464		
Perceived Barriers	0.447	0.545	0.287	
Cues to Action	0.454	0.711	0.56	0.476

Source: Prepared by the authors (2022)

Table 4. provides details about the demographic characteristics of the respondents. About 54.4 % respondents are female and 45.6 % are male. The majority i.e., 78.4% respondents are unmarried and 61.2 % of the respondents are from urban locality. 85 % of the respondents have not been infected with covid-19 at the time of data collection.

Table 4- Demographic Characteristics

	Number	Percentage
Gender		
Female	224	54.4
Male	188	45.6
Marital Status		
Married	89	21.6
Unmarried	323	78.4
Locality		
Rural	75	18.2
Semi-Urban	85	20.6
Urban	252	61.2
Previously affected by Covid		
No	350	85
Yes	62	15

Source: Prepared by the authors (2022)

Logistic Regression Analysis

A Total of 412 responses has been fed into Logistic Regression Algorithm with all the data being accepted since there are no missing values in the data. The Predicted Variable is respondent's intention to vaccinate and it's a binary categorical variable with two responses 'Yes' or 'No'. The Dependent Variables are being coded as follows; "Yes" -1, "No"-0. The Study has employed forward step wise regression using Likelihood ratio. The Forward Stepwise Logistic Regression begins with an intercept only model and keep on adding significant variables one at a time each step until the model meets with a stopping criterion by which the algorithm selects the best features out of the pool of independent variables. The Forward Stepwise Regression computed for four iterations adding four significant features into the model. Model Fit is determined using the omnibus test of model coefficients and the results are provided in Table 5.

Table 5 -Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	11.658	1	.001
	Block	11.658	1	.001
	Model	11.658	1	.001
Step 2	Step	6.274	1	.012
	Block	17.932	2	.000
	Model	17.932	2	.000
Step 3	Step	4.664	1	.031
	Block	22.596	3	.000
	Model	22.596	3	.000
Step 4	Step	10.368	1	.001
	Block	32.964	4	.000
	Model	32.964	4	.000

Source: Prepared by the authors (2022)

All the Four Steps are found to be significant and hence we can conclude that model is fit and there is a significant improvement to the Step 4 of the Model compared to the null model. Another Significant indicator of the model is fit is Hosmer and Lemeshow Test which says the model is a poor fit if the significance value is less than 0.05(Mehrolia et al., 2021) . Since the test result of the step 4 of the model is non-significant with chi-square = 6.072 and sig = 0.639 we can conclude that the model is a good fit. The Predictive Accuracy of the Model is explained by the confusion matrix provided by Table 6.

TABLE 6- CLASSIFICATION TABLE – LR

	Observed		**Predicted**		
			Itent to Vaccinate		**Percentage Correct**
			No	Yes	
Step 4	Intent to Vaccinate	Yes	0	394	100.0
		No	3	15	16.7
					96.4

Source: Prepared by the authors (2022)

The Model correctly predicts 96.4 % of the cases out of 412 cases, further the Model correctly predicts 100 % of the cases in 'Yes' Category and 16.7 % of the cases in No Category. The Model accuracy is very good, and hence it is proved to be a good classifier for predicting the intent of the public towards vaccination.

TABLE 7- SIGNIFICANT PREDICTORS OF FORWARD LR MODEL

Variables in the Equation							
		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1	Perceived Benefits	0.968	0.279	12.01	1	0.001	2.634
	Constant	-0.348	0.945	0.136	1	0.713	0.706
Step 2	Perceived Benefits	0.915	0.282	10.521	1	0.001	2.496
	Marital status (1)	-1.287	0.501	6.605	1	0.01	0.276
	Constant	0.275	0.993	0.077	1	0.781	1.317
Step 3	Perceived Benefits	1.173	0.331	12.515	1	0	3.231
	Perceived Barriers	-0.903	0.433	4.336	1	0.037	0.406
	Marital status (1)	-1.18	0.512	5.309	1	0.021	0.307
	Constant	2.603	1.608	2.621	1	0.105	13.499
Step 4	Perceived Benefits	0.77	0.376	4.18	1	0.041	2.159
	Perceived Barriers	-1.684	0.545	9.552	1	0.002	0.186
	Cues to Action	1.782	0.591	9.103	1	0.003	5.943
	Marital status (1)	-1.124	0.536	4.395	1	0.036	0.325
	Constant	0.104	1.684	0.004	1	0.951	1.109

Source: Prepared by the authors (2022)

Table 7. explains the provides the details of significant predictors affecting the respondent's intention to take up covid-19 vaccination. Inference of the logistic regression analysis has been done based on the discussion put forward by this significant research work(Mehrolia et al., 2021). The Forward Logistic regression has selected three HBM constructs i. Perceived Benefits with a positive regression slope (B = 0.77, p <0.05) ii. Perceived Barrier with a negative slope (B= -1.684, p <0.01), iii. Cues to Action with a positive slope (B = 1.782, p<0.01) and a demographic variable Marital Status (1) with a negative slope (B= -1.124, p <0.05). There exists a positive relationship between Perceived Benefits, Cues to action and public intention to get a covid-19 shot which denotes that probability of the respondent who intends to a get covid-19 vaccination shot was greater for those who has greater perceived benefits and cues to action. Similarly, the Probability of respondent intention to vaccinate was lesser for those who has greater perceived barriers. The Marital Status (1) which denoted the

category of respondents who are married has a negative relationship with intent to vaccinate. Rise in Perceived Benefits, Cues to Action are correlated with increase intent in respondents' intent to covid-19 vaccination however increase in Perceived barriers was linked with a decline in respondents' intent to vaccinate.   Other HBM constructs like Perceived Severity, Perceived Susceptibility and other Demographic variables did not seems to affect the public intention to vaccinate. The odds Ratio for the predictor variables were provided in the Exp(B) column Table 7 which denotes that the odds of a respondent who intends to get a covid-19 vaccination short varies by a factor of 2.159 with each raw score increase of perceived benefits, 5.943 with raw score increase of cues to action. OR values for Perceived Barrier denotes that the chances of a respondent who intent to vaccinate vary by a factor of 0.186 with every raw score reduction on the perceived barriers regarding vaccination. Similarly, the odds of having an intent to covid19-vaccination is 0.325 times lesser for a married respondent as opposed to their unmarried counterparts.

Artificial Neural Network

Machine Learning Algorithm Artificial Neural Network is used in conjunction with the Logistic Regression Analysis to identify the significant predictors impacting the respondent's intent to take up covid-19 vaccine. All the categorical demographic Factors are given coded as factors and given as inputs to the Model. HBM constructs and age in years are coded as covariates and given as inputs in the input layer. ANN is constructed with one hidden layer and seven units in hidden layers. Hyperbolic Tangent has been used as the activation function for the hidden layer. The Output Layer has two units and SoftMax being used as the activation function.

Table 8 -Normalized Variable Importance

Variables	Importance	Normalized Importance
Cues to Action	0.25	100.00%
Perceived Benefits	0.17	68.20%
Perceived Barriers	0.164	65.60%
Age (years)	0.105	42.10%
Monthly Family Income (INR)	0.046	18.60%
Perceived Severity	0.04	16.20%
Have you been affected by Covid	0.037	14.90%
Perceived susceptibility	0.035	13.90%
Marital status	0.034	13.60%
Chronic health conditions	0.033	13.20%
Has anyone close to you been directly impacted by the COVID-19 Pandemic?	0.033	13.20%
Area of location	0.027	10.70%
Education	0.014	5.70%
Gender	0.011	4.60%

Source: Prepared by the authors (2022)

Table 8.   provides normalized importance of the predictor variables based on the sensitivity analysis computation. The Variables with the highest level of normalized importance is Cues to Action (100 %), followed by Perceived Benefits (68.20 %) and Perceived Barriers (65.60 %). All the three Predictors identified above have more than 50 % normalized importance. The Results from the Artificial Neural Network model are found to be in line with logistic regression results as the variables perceived Barriers, Perceived Beliefs and Cues to action are found to be significant predictors in both in these models. The HBM variables such as perceived susceptibility and perceived severity are found to be insignificant in both the models.

Table 9 - confusion matrix artificial neural networks

Observed		Predicted		
		No	Yes	Percent Correct
Intent to Vaccinate	No	2	6	25.00%
	Yes	1	122	99.20%
	Overall Percent	2.30%	97.70%	94.70%

Source: Prepared by the authors (2022)

The Artificial Neural Network Algorithm correctly classifies 94.70 % of the cases. The Predictive accuracy of the algorithm is par with Logistic Regression which was able to correctly classify 96.4 % of the cases. Another Important metric in identifying the predictive accuracy of the model is area under curve. Greater the Value of AUC, Greater the performance of the classifier. The AUC value of the ANN model is 0.908 and it denotes that the model can correctly distinguish between the intent of the respondents to vaccinate to greater extent.

DISCUSSIONS

From the Results of the Logistic Regression and Artificial Neural Networks it is found that the variables Perceived Benefits, Perceived Barriers, Cues to Action of the Health Belief Model significantly affect the respondent's intention to vaccinate. The Policy makers and Stake Holders involved shall make significant strategies based on the above findings so that they can be well prepared in case of such a future pandemic situation. From the Results of Logistic Regression, it is evident that Perceived Benefits positively impacts the covid-vaccination intent of the respondents. Respondents who perceived that covid vaccination is beneficial to them had more intent to vaccinate. For Future Vaccination Drives, Government can plan for mass communication strategies involving advertisements in mass media, social media and other platform illustrating the benefits of the vaccine to the public so the benefits of the vaccine will reach the masses. More the positive public perception regarding the vaccination benefits more will be their intent to vaccinate. Similarly, from Logistic Regression it is also found that cues to action positively impacts the covid 19 vaccination intent. Cues to action involves the stimulus both internal and external which triggers the people to vaccinate. This involves advice from the health provider, workplace mandate, information about the variants from newspapers etc., Similar triggers can be planned in the future by the relevant stakeholders to encourage their concerned target group to get vaccinated. Perceived Barriers is negatively associated with respondents' intention to get vaccinated. This is a crucial finding for the study since the respondents who feel that there are many obstacles in taking a covid 19 vaccination like possible side effects, changes in regular routine, concerns regarding vaccine efficacy etc., are having lesser intent to take up covid 19 vaccination. Regular Communications clearing the concerns regarding the vaccinations shall be disseminated among the masses so that the public concerns regarding their apprehensions regarding the vaccine can be addressed. Counselling centers can be established at various places like malls, hospitals, and other places of public gatherings so that public can clear their apprehensions about the vaccine in privacy.

CONCLUSION

This Research Study on covid-19 vaccination intent utilizes the popular machine learning algorithms like Logistic Regression and Artificial Neural Networks to identify the significant features impacting the respondent's intent to take up covid-19 vaccination. Both the Algorithms presented Perceived Barriers, Perceived Benefits and Cues to action as significant variables of health belief model which are associated ed with the intention to vaccinate. Both the Machine Learning Algorithms performed with good classification accuracy with Logistic Regression

having a 96.4 % accuracy and ANN having an accuracy of 94.70 % which is a clear indication that the features identified by the model can predict the respondent's intent to vaccinate to a good extent. The research is important as it helps to understand the respondent's hygiene and health related behavior. The Findings from the machine learning analysis will help policy makers, Government bodies, organizations plan better strategies if we are face a pandemic in future which we hope not to.

LIMITATIONS OF THE STUDY

The Study has not analysed the sentiments of the respondents towards covid-19 vaccination using text mining and sentimental analysis techniques. The study findings are restricted to the factors identified by the health belief model only. There may be other factors apart from the health belief model constructs which can affect the respondents covid-19 vaccination intent which can be further explored.

SUGGESTIONS FOR FUTURE WORK

The Current study use logistic regression analysis and Artificial Neural Networks to predict the respondent's intent to take up covid 19 vaccination. Future studies can include other machine learning algorithms to name ensemble learning algorithms like random forest, adaptive boosting, and other such algorithms to predict the respondent's intent to vaccinate. Future studies can also include sentimental analysis of respondent's social media postings to understand their sentiments and perceptions regarding the covid-19 vaccination.

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