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### Vaccine Hesitancy Model for Health Informatics and Control of Covid-19 Infodemic

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# Vaccine Hesitancy Model for Health Informatics and Control of Covid-19 Infodemic

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## ABSTRACT

As the world fights the pandemic, the world is also fighting infodemic and vaccine hesitancy, coincident with the massive shifts in communication technology and developments through social media. The World Health Organization considered vaccine hesitancy as a top ten global threat to public health. This study examines the causes and effects of vaccine hesitancy and proposes a model that adopts the 3C model. A set of structured items intended to capture responses from 150 students in Nigerian Universities towards their intention about the COVID-19 vaccine was designed using the survey method. Their responses were analyzed using descriptive SPSS software programs. A soft modelling approach (Smart PLS) was used to evaluate the proposed model and analyze the relationships between the model constructs. The results indicate a high level of hesitancy among students. In contrast, respondents levels of confidence, complacency and convenience were high and motivated by misinformation. Based on the analyses of our findings, misinformation has reached crisis proportions regarding COVID-19 and vaccines; social media play a more role in these challenges leading to infodemic. This article turns the spotlight by looking at how misinformation can travel within social media and could be managed, including the best ways to control infodemic (infoveillance) using digital technologies.

**Keywords:** COVID-19 Infodemic, Infoveillance, Vaccine Hesitancy Model, Social Media. Software Digital technologies.

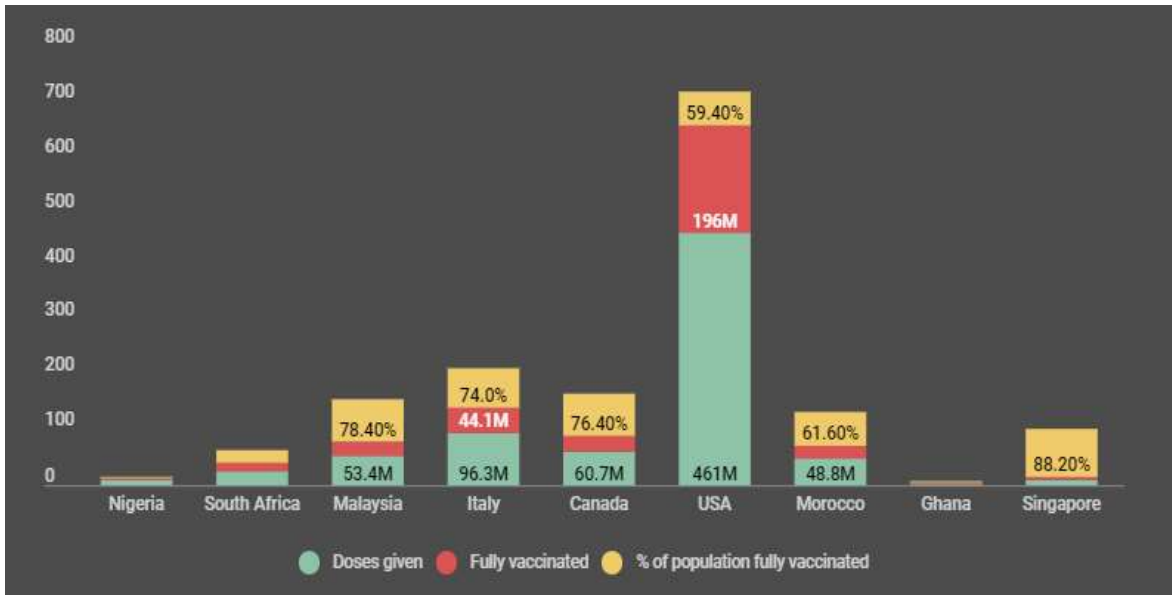
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## 1. BACKGROUND OF STUDY

After several months and since the first case of the epidemic, vaccine intervention was fully introduced in Nigeria to help manage the pandemic. The coronavirus disease (COVID-19) pandemic shocked the world in 2019, reporting the first case in Wuhan, China. The first case of COVI-19 was discovered in Nigeria on February 27, 2020. Nigeria, a country with 36 states and a Federal Capital Territory, was rated among vulnerable African nations to COVID-19 with less capability to confront and win the pandemic (Marbot, 2020). During the WHO's Joint External Evaluation (JEE) of Independent, Collaborative multi-sectoral effort to assess a country's capacity to prevent, detect, and respond to public health risks, Nigeria scored poorly both in prevention and response, suggesting Nigeria may not be able to manage a future case of a disease outbreak (Talisuna et al., 2019), however, during the case management of COVID-19 pandemic, the intervention and strategy put in places revealed that Nigeria had developed some capabilities to detect new health risks through real-time surveillance and health monitoring. The most apparent evidence was Nigeria's public health response to the COVID-19 pandemic and strategies to control a pandemic, including compliance to screening, containment (or suppression), and upfront readiness to administer the COVID-19 vaccine Nigeria.

As of June 2021, Nigeria has recorded 175 264 confirmed cases of COVID-19 with 2,163 deaths (NCDC, 2021). The Coronavirus disease (COVID-19) vaccine has been validated for use by WHO to serve as strong protection against the virus. The first COVID-19 vaccines have already begun to be introduced in countries, including low- and middle-income countries. As of November 2021, Nigeria had administered over 9.85 million doses of the AstraZeneca vaccine, which began on November 30, 2021; 9.5million doses have been given, 3.52M Nigerians have been fully vaccinated at just 1.7% out of 200 million population of Nigeria (WHO, 2021a).



**Figure 1. Statistics of Vaccine doses, Fully Vaccinated percentage. Data Sources From (WHO, 2021a)**

The COVID-19 vaccine program from the WHO shows the total number of doses given in some countries and the number of fully vaccinated people as of November 30, 2021. According to (WHO 2021a), the data changes rapidly as doses are constantly updated from resources worldwide. Accessing the number of vaccines given to Nigeria and the percentage of fully vaccinated, the figure is small and likewise in many other African Countries. Yet, the Coronavirus pandemic and vaccine program has been accompanied by an unprecedented 'infodemic' (Kobayashi, 2021; WHO, 2021b).

Most of the research efforts and interventions have examined the cause of vaccine hesitancy (Dereje et al., 2021; Fisher et al., 2020; Freeman et al., 2020; Schwarzingler & Luchini, 2021), the challenges can be further promoted with the massive shifts in communication technology and associated economic structures for monetizing information online. Social media such as Twitter, Facebook and other platforms has played a major role in Infodemic crisis. For example, nearly 40% of Americans viewed content from social media where "fake news" may be highly prevalent. More people and students in Nigeria consume news online through social media (Awofeso, 2020). According to (West & Bergstrom, 2021), information through social media sources is dangerously hyperpartisan. Much research has modelled the spread of and dynamics of falsehoods through social media (Bergstrom & Bak-Coleman, 2019; Vosoughi et al., 2018).

Therefore, public support and effort to control the spread of misinformation about severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is being undercut by misinformation, leading to the World Health Organization's "infodemic" declaration (Broniatowski et al., 2020; WHO, 2021b). The World Health Organization (WHO) described Infodemic as a "large increase in the volume of information associated with a specific issue and whose growth can occur exponentially in a short period due to a specific incident, such as the current COVID-19 pandemic" Infodemic is spread along with manipulation of information with doubtful intent. In the technological age, Infodemic is amplified through social networks (WHO, 2021b). An average Nigerian student has broad access to the internet and smartphones with an internet connection, making them more active on social media. Recent research findings have indicated that average Nigerian undergraduate students are the heaviest users of Social Media networks such as YouTube, Facebook, Twitter, Instagram and WhatsApp, (Lau, 2017). This medium has contributed to the spread of messages regarding the COVID-19 Vaccine capable of causing vaccine hesitancy.

Vaccine hesitancy refers to a delay in accepting or refusing vaccines despite the availability of vaccine services (WHO, 2020a). Vaccine hesitancy is a complex phenomenon closely linked to social contexts with different origins such as political situation, geographical area and new media. Irrespective of factors for vaccine hesitancy, variances of concern have emerged on their impact on the COVID-19 endpoint. At the first infodemiology conference organized by the WHO, infodemic messages have been on a rampage using information systems to send messages revolving around core emotions and values. The misinformation often hijacks people's mental cues towards vaccination. In a recent survey on COVID-19 related messages across social networks, a team of infodemic management and epidemiologists collected and reviewed 637 messages across 52 countries on COVID-19 Vaccine (s) information circulating globally on the social media platforms; a significant amount of the messages were flagged as rumours and conspiracy that can be described as 'infodemic messages capable of causing peoples refusal to vaccinate, (Islam et al., 2021).

Some of the infodemic messages, according to (Islam et al., 2021), are related to conspiracy theories such as " COVID-19 vaccines are no different from the flu vaccine" after vaccination against COVID-19 in Africa, the population will decrease", "COVID-19 vaccine will cause infertility" COVID-19 vaccine may not be effective and has serious side effects". The term infodemic has been phrased to outline the perils of misinformation phenomena during the management of disease outbreaks (Cinelli et al., 2020). (Kim et al., 2019) argued that infodemic could speed up an epidemic process and endangers the well-being of the world.

Therefore given the heterogeneity of the social media, the risk posed by COVID-19 related infodemic campaign to the international peace, we cannot solve problems of public health without also addressing the growing problem of misinformation and the repercussions of spreading them through the social media as the media provide fertile ground for 'organic' false information and conspiracy theories accompanying the Coronavirus infodemic and vaccine hesitancy. As a motivation, this study would be led by the following research questions.

- RQ1: What are the predicting factors for vaccine hesitancy among students in Nigeria?
- RQ2: What are the impact of misinformation in the media on vaccine hesitancy

## 2. RELATED WORKS

Vaccine hesitancy remains the next challenge the world faces in the fight against COVID-19 (Ali et al., 2021; Chadwick et al., 2021; Dror et al., 2020; Schwarzinger et al., 2021). In June 2020, (Lazarus et al., 2021) surveyed 3,426 people in 19 countries to determine possible acceptance rates and factors influencing acceptance of a COVID-19 vaccine, 71.5% of the people surveyed suggest that they will be reluctant to receive COVID-19 vaccination. That was even when the pandemic was at an intense stage. Vaccine hesitancy is a critical issue in Africa and the world in general, with much concern that people are asking genuine questions about the benefits and safety of vaccination (Fisher et al., 2020). Hesitancy amongst the general public and public officers was revealed (Dubé et al., 2015). Obregon reported vaccine hesitancy among the general public. (Mant et al., 2021) Investigate vaccine hesitancy among university students and their willingness to receive a COVID-19 vaccine. However, the study revealed majority of university students intend to get the COVID-19 Vaccine; there are some concerns about vaccine efficacy and safety. At the same time, (Zewude & Habtegiorgis, 2021) reported vaccine acceptance among school teachers, university instructors and bank employees in Africa.

According to the World Health Organization (WHO), there is global vaccine hesitancy even though some countries struggle with vaccine rollout (WHO, 2020b). According to existing studies and Health Believe Theory, several factors are responsible for vaccine hesitancy (Wolff, 2021; Yahaghi et al., 2021). (Uzochukwu et al., 2021) investigate factors responsible for vaccine hesitancy among staff and students in a Nigerian tertiary educational institution using an online survey. However, the result shows that vaccine hesitancy is high among staff and students in a Nigerian university and is significantly influenced by individual beliefs and socio-cultural beliefs. A study based on a field experiment in rural northern Nigeria measured the prevalence of vaccine hesitancy among adults; the study revealed a deep concern on absolute refusers of people with a negative willingness to vaccinate (Sato & Takasaki, 2021).

In a student community, media outlets, mainly social media, play a crucial role in vaccine hesitancy; among the influence of the media on student vaccine hesitancy were misinformation and Infodemic spread through Social media platforms (Islam et al., 2021). According to new research by (Chadwick et al., 2021), there is variation in vaccine hesitancy factors across countries and contexts. Several studies have been conducted in the context of adult and general vaccine hesitancy among people. University-aged students are a unique demographic group focused in this study as they are with underlying illness experiences and high media and information consumption habits.

### 2.1. Vaccine Hesitancy and Predicting Factors

Vaccine hesitancy has been described as refusing to take up the Vaccine due to several factors and concerns (Yaqub, Castle-Clarke, Sevdalis, & Chataway, 2014). Vaccine hesitancy can affect any immunization program in the world (WHO, 2020b). According to (Rachaniotis, Dasaklis, Fotopoulos, & Tinios, 2021), vaccine hesitancy has thus remained a complex public health issue many countries face. According to (Dror et al., 2020), vaccine misinformation and misconceptions have been significant barriers to vaccine uptake. In Africa, false information and conspiracy theories discourage the public from getting vaccinated (Awofeso, 2020). The Africa Centres for Disease Control and Prevention (Africa CDC) have surveyed 15 000 respondents between August-December 2020 across 15 African countries, though (79%) of the population surveyed revealed they would take the COVI-19 Vaccine.

However, "if it were deemed safe and effective" (Adaeze Aroh 2021). According to the (NPHCDA, 2021), seven out of ten people may likely decline to accept the vaccines due to several factors. Some of the predicting factors vary, lack of trust and access barriers, personal belief (Siciliani et al., 2020), high perception of risk, and low confidence in the Vaccine (Mills, Jadad, Ross, & Wilson, 2005), misinformation across the media and conspiracy theories(Dror et al., 2020; Islam et al., 2021; Loomba et al., 2021), including lack of awareness about the vaccine benefits and recommendations (Awofeso, 2020; Ozawa et al., 2020).

According to the World Health Organization (WHO, 2020a), vaccine hesitancy is majorly influenced by three factors: confidence, complacency, and Convenience. However, individuals tend to be **vaccine-hesitant** for different **reasons, including** personal negative experiences and misinformation regarding the vaccines (Quinn, Jamison, Hancock, & Freimuth, 2019). Various models have been suggested to capture the main predicting factors for vaccine hesitancy. The model described in figure 2 has been revised and accepted by the Strategic Advisory Group of Experts (SAGE) on disease immunization (WHO, 2020).

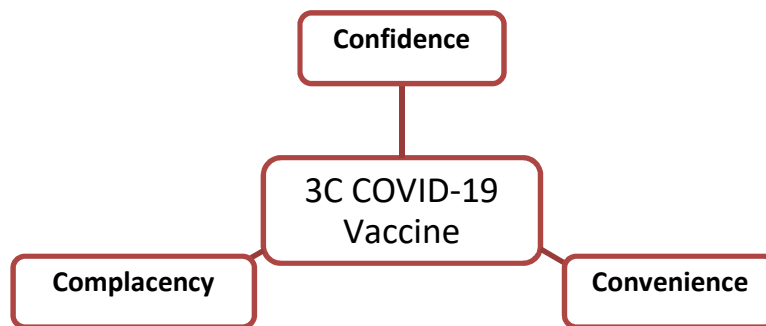


Figure 2. Vaccine Hesitancy Model

## 2.2 Theoretical Framework

Based on the problem statement, there is global concern on vaccine hesitancy and variation in factors for individual actions. One of the critical areas that have been overlooked is the impact of technology and social media network on vaccine hesitancy. Several studies have been conducted in the context of adults using the 3C model. Investigating University-aged students' intention to vaccinate can be looked through the information they consumed online; apart from having several underlying illness experiences, they have high media and information consumption habits that can lead many students to delay vaccinations and put the academic community at risk, thus forming a critical barrier and motivation for this study. Thus the research was modelled using the 3C model, Confidence, and Convenience Complacency as used in several sociomedical literatures and used in making complex vaccination decisions (MacDonald, 2015). Among students in Nigeria, vaccine hesitancy is a critical issue and can be linked to the influence of social media. According to (Hou et al., 2021), social media plays a significant role in providing fast information on disease outbreaks and can influence students' understanding of and behaviour in public health emergencies. The study considers social media influence, complacency, Convenience and confidence as the research mediating variables impacting vaccine uptake among students with the proposed framework in figure 3.

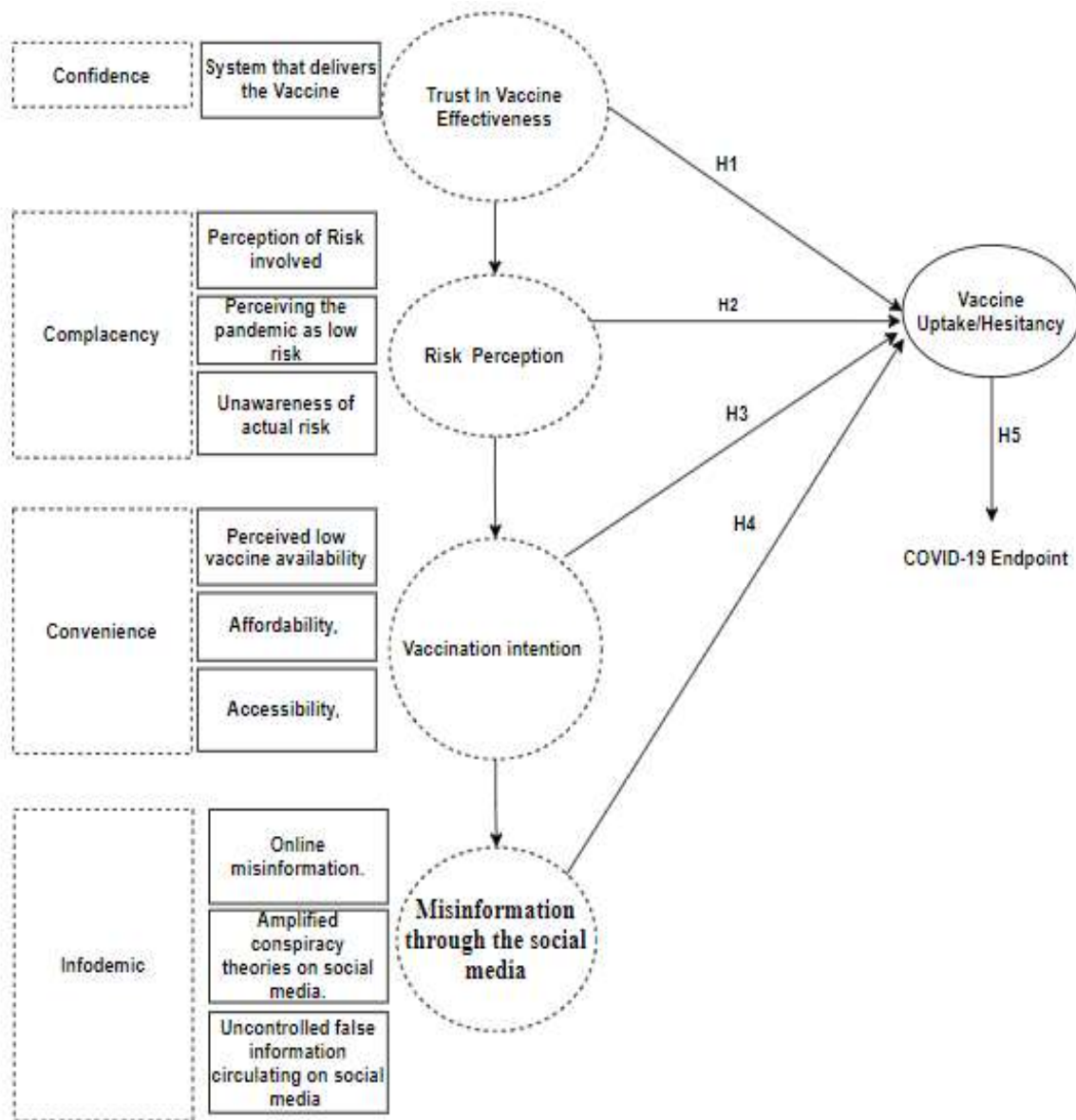


Figure 3. Infodemic and Vaccine Hesitancy Framework

## 2.3 Measurement of Variables

### 2.3.1 Confidence:

Confidence is the degree of trust in the effectiveness and safety of the Vaccine, including the competence of the health services and health professionals (Schuster et al., 2015). According to (Fisher et al., 2020; Mills et al., 2005; Yaqub et al., 2014), lack of confidence is caused by strong negative attitudes towards vaccination, which can be influenced by misinformation about vaccination safety and effectiveness of the vaccination. Distrust in the vaccination: Trust is one of the significant challenges facing the immunization program in Nigeria. Many studies have reiterated that vaccines save lives and are efficient (Li et al., 2021; WHO, 2020a).

According to (Lazarus et al., 2021), a large proportion of strongly hesitant people have postponed their decision to take vaccines due to trust issues and lack of conviction (Schwarzinger & Luchini, 2021).

### **2.3.2 Complacency**

Complacency results as a combination of risk perception and prejudices relating to side effects and other reactions from the Vaccine (Hornsey et al., 2021). The degree to which complacency determines hesitancy is related to the high perception of risk and confidence. Complacency has been looked at from risk perception, which is constantly spread through social media rumours. According to (Hornsey et al., 2021), strongly hesitant people towards vaccination are individuals with risk concerns. Complacency is also higher among people within a low social demographic context (Galarce, Minsky, & Viswanath, 2011). According to (SteelFisher, Blendon, Bekheit, & Lubell, 2010), Demographic, social context may have significant implications for vaccine uptakes.

### **2.3.3 Convenience**

The Convenience of the Vaccine is defined by availability, affordability, willingness to get vaccinated, ability to understand and accept vaccine-related information even despite immunization services appeal, and quality of care from experts and community leaders (Schwarzinger & Luchini, 2021). According to the SAGE Working Group, the motives are enabling environment, social influences, and motivation, which form the basis for vaccination uptakes (González-Block et al., 2020).

### **2.3.4 Information Shared Online**

With the technological and media advancement, it is getting challenging toward the social media as an influencing factor for vaccine uptake, especially among students. The influence of media on vaccine uptake and hesitancy has been reported in many African countries to varying degrees (Mtewa et al., 2020). Media referred to includes Television, radio, newspapers, magazines, medical journals, books, pamphlets and popular social media outlets such as Twitter, Facebook, Youtube and Whatsapp, (Belsti et al., 2021; Dzinamarira et al., 2021; Enitan et al., 2020). According to (Adebisi et al., 2021; Puri et al., 2020), social media have influenced COVID-19 vaccine hesitancy and uptake among people in Africa. For instance, in South-eastern Africa, a study was conducted among 513 respondents by (Belsti et al., 2021) on the sources of information for COVID-19. The study revealed that 31.8% used social media as their sources of information for COVID-19. Consequently, in a study conducted by (González-Block et al., 2020) (Broniatowski et al., 2020), social media was more prone to sharing infodemic messages, unverified, false and inaccurate information regarding COVID-19. Therefore the following hypotheses were proposed

- H1: confidence (trust in vaccine effectiveness, safety, and the system that delivers it) have direct mediation on vaccine uptake
- H2: complacency (perceiving the disease as low risk) directly mediates vaccine uptake among students.
- H3: Convenience (perceived low vaccine availability, affordability, accessibility, and other barriers to vaccinating) directly mediates vaccine uptake among students.
- H4: Uncontrolled false (Infodemic) circulating on social media have direct mediation on vaccine uptake among students
- H5: Vaccine Uptake/hesitancy has a direct effect on the COVID-19 endpoint



### 3. METHODOLOGY

#### 3.1 The Research Design

Structured survey questions were designed and distributed electronically via Qualtrics XM and anchored using a five-linkers scale at strongly agree (5) and *Strongly Disagree* (1) to test the mediating variables stated in the proposed hypothesis and their correlation with individual vaccine uptake. The study population comprised 150 students from a University in Nigeria using random sampling. Data collection took place between June 4 –July 18, 2021. The study design is purely quantitative and designed based on the proposed hypothesis. Ethical approval was granted by the Research Ethics Committee of the BC Networks Research Institute, Nigeria. Though informed consent was requested on the introductory web page before the survey enrollment, students' participation was voluntary. Confidentiality of information was assured. Participants were allowed to terminate their participation at any time. The main questions in the survey were opened with COVID-19 vaccine intention. (1) I will take up the Vaccine when offered; (2) I will probably not take the Vaccine. The survey further asked questions that warrant their decision, including related to the hypothesis's constructs. A reliability test of the questionnaire was performed using Cronbach's Alpha and to assess the internal consistency of a survey instrument. Descriptive statistics with IBM SPSS V.20 was used for the statistical analyses. A PLS algorithm was used to measure the path model estimation and show how the variables in the proposed model were connected.

#### 3.2 Specifying the Structural Model

There are eight (8) latent variables in the model of this study, and the variables were derived from the 3C model: trust towards the vaccine (Confidence), risk and effectiveness of the Vaccine (Complacency) and vaccination intention (Convenience). The construct reliability and validity were tested, and the path model was run to establish the model's goodness-of-fit.

#### 3.3 Construct Reliability and Validity

In this study, construct validity was conducted to establish the validity and reliability of the instrument by calculating its composite reliability and Average Variance Extracted (AVE). Though the items for the variables were extracted from existing literature, some of them were revised and rewarded; therefore, it was necessary to ensure content validity to reduce measurement errors. The Cronbach's Alpha was used to assess the internal consistency of a survey instrument. According to Hinton et al. (2004), there are four cut off values to measure reliability: i.e., if the value is (0.90 and above), excellent reliability; (0.70 - 0.90), high reliability; (0.50 - 0.70) moderate reliability; and low reliability if < 0.50. The Cronbach's Alpha is between (0.50 - 0.70) as was obtained by using IBS SPSS 24. Table 4 presents the values and the Construct Reliability and Validity.

**Table 1: Construct Reliability and Validity**

	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
Risk factors (Complacency)	0.562	0.594	0.771	0.533
Trust and Perceived Effectiveness of the Vaccine (Confidence)	1.000	1.000	1.000	1.000
Vaccination Intention (Convenience)	0.098	0.153	0.542	0.279
Information shared online	0.093	0.148	0.432	0.179
Vaccine Hesitancy	1.000	1.000	1.000	1.000

#### 4. DATA PRESENTATION

Descriptive statistics were used to analyze, screen the descriptive questions based on (5) points Likert Scale ranging from strongly agree (5) to strongly disagree (1), while structural equation modelling (SEM) technique was used to examine the extent of relationships between the constructs of the model and test the hypotheses. The essence was to establish the relationship between two variables (independent and dependent variables) and test the indicator variables and structural paths coefficients. The output validity and reliability were also generated using SmartPLS. The responses collected from the survey consist of different demographic information; all respondents are students. People below 18 years were excluded from the survey. The total number of responses collected was 150; hence the final data consists of 150 responses subsequently analyzed using SPSS. See Table 1. From 150 respondents in this study, 65 responses were received from female respondents (43.3%), and 85 responses were from male respondents (56.6%).

**Table 2: Respondents Profile**

	Frequency	Percentage
<b>Sex:</b>		
Male	85	56.6
Female	65	43.3

Source: Fieldwork: 2021

#### 4.1 vaccinations Uptake and Intention

The students were asked if they had taken the COVID-19 Vaccine and if they would take it when offered. From table 3, the analysis indicated that on average, 57(37.2 %) of the respondents affirmed that they are yet to get the COVID-19 Vaccine

**Table 3. Vaccination Status and Intention**

	Frequency	Strongly agree %	Agree %	Undecided %	Disagree %	Strongly Disagree %	Total %
1. I will take up the vaccine when it is offered	12 (8%)	20 (13.3%)	13 (8.6%)	35 (23.3%)	65 (43.3%)	150 (100%)	
2. I will probably not take the vaccine	33 (22%)	39 (26%)	40 (26.6%)	20 (13.3%)	18 (12%)	150 (100%)	

From table 3, 65 (43.3%) of the students revealed they would not take up the Vaccine even when it is offered, 40 (26.6%) among them strongly disagreed they will not take the Vaccine, while 12 (8%) and 20 (13.3%) strongly agreed and agreed to take the vaccine when it is offered. Similarly, some participants expressed optimism about taking the Vaccine as 33 (22%) revealed they may take it. Based on the two opening questions for vaccine intention, one can submit an average probability of students taking the Vaccine. However, **there** are some motives behind 40(26.6%) of the respondents who have yet to decide if they will or will not take the Vaccine. The following questions were presented to them to rate using (5) pint Linkert scale. Strongly agreed (S.A.) Agree (A) Undecided (U) Disagreed (D), Strongly Disagreed (S.D.).

**Table 4. Descriptive of student response towards the 3Cs attitude to COVID-19**

Questions	SA	A	U	D	SD	TOTAL
I have confidence and trust in the vaccine and I am eager to get a COVID-19 vaccine	12 (8%)	20 (13.3%)	13 (8.6%)	65 (43.3%)	40 (26.6%)	150 (100%)
I am not bothered about getting a COVID-19 vaccine due to my level of trust in it	33 (22%)	39 (26%)	40 (26.6%)	20 (13.3%)	18 (12%)	150 (100%)
I believe so much in the vaccine information spread on line (Confidence)	39 (26%)	26 (17.3%)	44 (29.3%)	18 (12%)	23 (15.3%)	150 (100%)
The level of risk I perceived mediate my intention not to get vaccinated (Complacency)	44 (29.3%)	27 (18%)	44 (29.3%)	13 (8.7%)	22 (14.7%)	150 (100%)
I Would rather not say I will get the vaccine (Convenience)	23 (15.3%)	20 (13.3%)	64 (42.7%)	18 (12%)	25 (16.7%)	150 (100%)
Social influence and self believe mediate my intention to get vaccinated	29 (19.3%)	36 (24%)	48 (32%)	15 (10%)	22 (14.6%)	150 (100%)
I have heard a lot about the rumour and shared same online	21 (14%)	23 (15.3%)	46 (30.7%)	38 (25.3%)	22 (14.7%)	150 (100%)
I have heard a lot about the rumour and influenced my friend about it	42 (28%)	34 (22.7%)	39 (26%)	17 (11.3%)	18 (12%)	150 (100%)

**4.2 Test of Hypothesis and Mediation between Variables**

In path analysis and structural equation modelling, a path coefficient is the partial correlation coefficient between the dependent and independent variables, adjusted for other independent variables. A PLS algorithm was used to measure PLS path model estimation and show how these variables (Risk Factors and Vaccination Intention) mediate vaccination uptake, significantly impacting the epidemiological endpoint. The figure below shows the Path Model after calculating the PLS algorithm.

**Table 5. Mediation analysis**

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics ( O/STDEV )	P Values
Trust and Perceived Effectiveness of the Vaccine mediate the Risk factors which have direct mediation on vaccine uptake (Confidence)	-0.012	-0.012	0.022	0.533	0.594
Perception of Risk of the vaccine have direct mediation on the vaccination Intention among students (Confidence)	-0.028	-0.026	0.041	0.699	0.485
Risk factors mediate Vaccination Intention and consequently have direct mediation on Vaccine uptake among students (Complacency)	-0.005	-0.005	0.009	0.582	0.561
Vaccine intention mediate vaccine uptake among students due to perceived risk and trust	0.05	0.061	0.036	1.399	0.163
Nature of information shared through social media (Infodemic) have direct effect on vaccine uptake among student	-0.031	-0.032	0.044	0.709	0.479

**4.3 Path Model of Predicted Relationship Between Variables**

Path analysis was used to test the theoretical propositions of the model using the PLS-SEM approach. The study *assumes* some variables are causally related to vaccine uptake and hesitancy among students, including Confidence, complacency, confidence and nature of information shared regarding the COVID-19 vaccine through social media. The path model represents how the indicator variables are connected to the constructs and the relationship between constructs. It would be observed that most of the constructs are endogenous; that is, they have at least one construct playing the predecessor role.

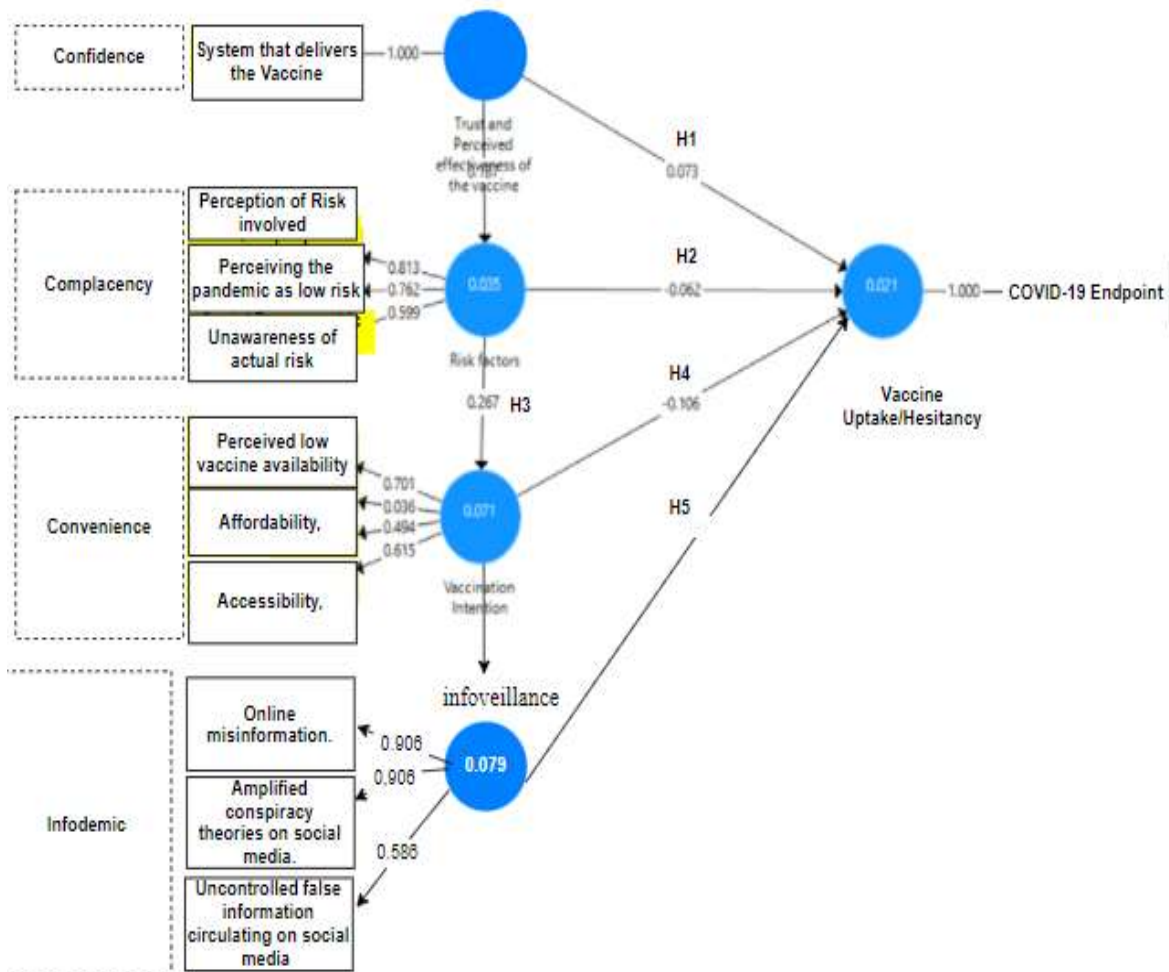


Figure 4. Structural Model for COVID-19 Vaccine Hesitancy and implication on Vaccine Uptake.

## 5. DISCUSSION OF FINDINGS

This study makes significant theoretical contributions, especially in understanding the predicting factor for vaccine hesitancy. Based on the mediation analysis, vaccine hesitancy is influenced by the level of confidence and trust students have in vaccine effectiveness, including the safety and the system that delivers it. Only 21.3% of 150 respondents strongly agreed that they have confidence and trust in the vaccine. 105 (69.9) revealed they did not trust the vaccine, as shown in table 4. Therefore, a growing concern on the population that disagrees that they will take the vaccine if offered is alarming; based on the responses highlighted in table 3, the study revealed some lack of confidence and trust in the vaccine. Trust in vaccination is very critical for vaccine uptake to be improved. Not surprising, trust in the vaccines has been seriously tested by recent reports causing a causal link to the Oxford/AstraZeneca vaccine hesitancy revealed trust (Confidence) as a positive predicting factor to accept the vaccine among students (Lazarus et al., 2021; Vergara et al., 2021). The study complements the existing findings by demonstrating a significantly higher intended COVID-19 vaccine hesitancy based on confidence and trust factors.

At the same time, there is concern over the risk perceived (complacency) as some respondents still perceived the pandemic as low risk. Based on the findings from this study, 71 out of 150 respondents revealed they are concerned about the risk involved. In contrast, their responses suggest they perceived the pandemic as low risk and the vaccination as high risk. 47.3% of the respondents show a higher perceived risk (complacency in the vaccine), thus affecting their vaccine uptake and intention to vaccinate. (29.3%) did not decide on their level of perception either towards the pandemic or the vaccine. Based on the Health Belief Model (Taylor et al., 2006), Theory of Planned Behavior (Wolff, 2021), Complacency is a substantial prevalence of COVID-19 vaccine hesitancy. Therefore proper sensitization towards the risk of the pandemic is needed among students for adequate COVID-19 vaccine uptake. On the other hand, among the psychological antecedents of vaccination hesitancy, as proposed by (Dror et al., 2020; González-Block et al., 2020), convenience is another predicting factor. Convenience was examined in different ways, based on the perceived low vaccine availability, affordability, accessibility, and other barriers to vaccinating. In Nigeria, and the state the study was conducted (Kwara State), COVID-19 vaccines are free; however, based on the places this researcher is only in the urban areas, a specific number of vaccines are administered per day.

Moreover, the characteristics of the interviewees revealed they are aware of health facilities closer to them for vaccination uptake. So concerning what might make it difficult for them to get the Vaccine, perceived low vaccine availability and accessibility played in. Based on accessibility, the respondents revealed accessibility is not a barrier for not being vaccinated, and neither they perceive low vaccine availability; only 23(15.3%) strongly agreed they would get the Vaccine at their will, 63(42) disagree not to get the vaccine even if they are convenient. 64(42.7%) remain undecided. The findings still fall on complacency (perceiving the disease as low risk) and confidence (trust in vaccine effectiveness, safety, and necessity, and the system that delivers it) as suggested in (Betsch et al., 2018).

However, it is essential to trace the built-up of students' perception and attitude towards COVID-19 vaccine acceptance. The study traced the perception to social media listening (infoveillance) as called in (Hou et al., 2021), mis-infodemic as suggested in (Awofeso, 2020), social media infodemic as revealed in (Broniatowski et al., 2020; Cinelli et al., 2020). Although not all respondents believe in social media listening (infoveillance), however, 65(43.3%) of the total respondents believe in the infoveillance messages spread online, 44(29.3%) did not decide. At the same time, 41(27.3) revealed they did not believe the information regarding COVID-19 shared online except reliable sources.

## 6. CONCLUSION

COVID-19 vaccine hesitancy is prevalent worldwide; significant causes of vaccine hesitancy have been discussed in this study. While we must promote confidence in the vaccine issue surrounding trust, safety, vaccine effectiveness not only has direct mediation on vaccine uptake among students alone but must be addressed by governments and public health practitioners. They must communicate the Vaccine's benefits to the people and side effects if any, and the world must deliver vaccines safely and effectively with the best of standards. Nonetheless, anti-vaccine information and infodemic are spreading over social media with negative tweets that have attracted higher engagement, thus having an adverse effect on COVID-19 vaccines, inciting fear in many people. For example, in a similar study by (Dereje et al., 2021), on the COVID-19 vaccine acceptance rate among university students and employees, all those who registered hesitancy cited social media as their source of information.

Governments must enhance public confidence, trust and design community engagement strategies for COVID-19 vaccine rollouts to ensure universal vaccination coverage. At the same time, COVID-19 vaccine risk misconceptions can be addressed through digital technologies, including social media. For instance, real-time data are posted on social media platforms. The same data can quickly identify public attitudes towards the ongoing Vaccine and future vaccination programs. They can be used to support health communication and health promotion messaging. However, with the increasingly widespread use of social media and smartphones among students and based on the findings of this study, the potential for the spread of infodemic messages, fake news through social media is high. Therefore this study suggests the best way to fight such infodemic (infoveillance) from the perspective of the first "infodemiologist," four pillars of infodemic management (Eysenbach, 2020):

- Information monitoring
- Enabling strong eHealth Literacy and social media literacy capacity
- Encourage knowledge refinement and quality improvement processes such as fact-checking and peer-review.
- Accurate and timely knowledge translation to minimize fact distortion by political or commercial influences.

The study contributes to infodemic management through theoretical and practical contributions by suggesting thorough information surveillance and proper social media monitoring about COVID-19 using Artificial Intelligence and analytics. While it is crucial to meet the public's demand for COVID-19 efficiencies, safety, accessibility and sincerity, more behavioural intelligence data is needed and can be achieved using Artificial Intelligence and analytics to track and clamp down infodemic related messages regarding COVID-19 and vaccines. Lastly, while the Vaccine will soon begin another phase of rollout in Nigeria, there is a call to use digital technologies like cloud-based vaccine management solutions to track vaccinations, hesitancy and side effects.

#### **Conflict of Interest**

The authors declare that the research was conducted without any commercial or financial gain that could be construed as a potential conflict of interest.

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