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COVID19 Vaccine Intentions in South Africa: Health Communication Strategy to Address Vaccine Hesitancy

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Abstract

Background: Widespread vaccine acceptance is key to achieving herd immunity through vaccination against COVID19, especially because the available vaccines do not have 100% efficacy. The continued infection amongst the unvaccinated can lead to heightened risk of further virus mutation, exposing even those vaccinated to new virus strains. Therefore, there are social benefits in minimising vaccine hesitancy. The objective of this study is to assess the level of COVID19 vaccine hesitancy in South Africa, identify the socio-economic patterns in vaccine hesitancy and to develop a targeted health communication strategy based on the HBM and EPPM models in order to improve vaccine acceptance.

Methods: The study uses the nationally representative National Income Dynamics Study - Coronavirus Rapid Mobile Survey (NIDS-CRAM) survey. The analysis combines univariate and bivariate statistics together with multivariate regression models like binomial/ordinal logit and seemingly unrelated regressions.

Results: The study finds that vaccine acceptance is lower than that of non-pharmaceutical intervention life face-mask use. Only 55% are fully accepting of the vaccine, while a further 16% are moderately accepting of vaccines. Together, vaccine acceptance is estimated at 70.8% and vaccine hesitancy against COVID19 is estimated at 29.2% amongst the adult South African population. The reasons cited for vaccine hesitancy are primarily due to concerns regarding the side-effects and efficacy of vaccine.

the study has identified perceived risk of infection with the mediating role of efficacy as a key predictor of vaccine intention. Apart from vulnerability to infection, those perceiving higher severity of risk (elderly and those with chronic illness) have lower hesitancy. Higher awareness of COVID19 related information and higher household income are correlated with lower vaccine hesitancy. The non-black African population group has significantly high vaccine hesitancy compared to black Africans. Males on average have lower hesitancy compared to females, and unmarried/unpartnered individuals are found to have higher hesitancy.

Conclusions: There are other significant differences across socio-economic and demographic variables in vaccine hesitancy. From a communication perspective, it is imperative to continue risk messaging, hand in hand with clearer information on the efficacy of the vaccines

1. Introduction

While the focus of protective behaviour for the first year of the COVID19 pandemic relied on non-pharmaceutical interventions (NPI), with the successful development of various COVID19 vaccines, the available approaches to protective behaviour in South Africa are expected to widen to include pharmaceutical interventions in the form of vaccines in the near future. Previous studies have shown that acceptance of NPI based protective behaviour is high in South Africa and has improved from 92% in May-June 2020 to 97 % in July-August 2021 as the pandemic progressed [1, 2]. However, the secondary effects of NPI and vaccines can be very different and therefore the behavioural response to both can differ substantially. Hence it is timely to assess the vaccine intentions of the population with a view to put in place measures to improve vaccine acceptance.

The focus of government has now shifted to making vaccines available and its roll-out strategy. It is equally important to work towards ensuring the public uptake of vaccines once they become widely available [3]. While the President of South Africa has announced that vaccination against COVID19 would be purely voluntary, large scale vaccine uptake is required to ensure its effectiveness. This is because the success of the vaccination programme depends upon achieving a scale that is sufficient to result in community immunity. Further, continued infection amongst the unvaccinated can lead to heightened risk of further virus mutation, exposing even those vaccinated (against the earlier strains of the virus) to new virus strains [4]. Therefore, there are social benefits in minimising vaccine hesitancy.

Pre-COVID19 studies have acknowledged that behavioural response against vaccination can be specific to a particular vaccine depending on the perceived risk of infection as well as the confidence in the vaccine [5]. [6] has highlighted the wide variation between COVID19 vaccine acceptance between countries. It is therefore highly relevant to assess vaccine intentions in South Africa with regard to the COVID vaccine and explore ways to improve vaccine acceptance in the general public health interest.

Various studies have shown that health communication has an important role to play in influencing individual response to health risks [7–9]. Hence it is imperative to develop a health communication strategy aimed at encouraging individuals to accept both NPI as well as vaccination against COVID19.

While different theories and models have been put forth by health communication theorists designed for health messaging, the Health Belief [10] and the Extended Parallel Process (EPP) [11, 12] models are most suited in the pandemic context because of their foundation on fear appeal or health risk [13, 14]. Meta-analyses of fear appeal messages have found that manipulations of fear appeals have an impact on attitudes, intentions, and behavior changes [15, 16]. Therefore, understanding the constructs of risk and efficacy using fear appeal theories such as Health Belief Model (HBM) and Extended Parallel Process model (EPPM) to encourage protective behaviour against COVID19 can be useful.

Health Belief Model (HBM) is one of the earliest health models to use key risk perception variables along with efficacy and barriers to behavioural response to predict health response behaviour [10]. The four pillars of HBM model are risk susceptibility/vulnerability, risk severity, efficacy, and barriers to behavioural change.

EPPM builds on this foundation using also the tenets of the parallel process model (PPM) [17] which distinguished between two independent reactions to fear appeals, viz, (a) a cognitive response of risk management process, leading to protective behaviour, and (b) an emotional response of fear management process, that leads to denial, and avoidance. While PPM did not explain the contexts when either of these responses is evoked, EPPM extends the PPM to incorporate the four elements (the perceived severity of a threatening event, the perceived vulnerability, the response efficacy of the recommended preventive behaviour, and the perceived self-efficacy) of Protection Motivation Theory (PMT) [18] to explain this.

The extended parallel process model (EPPM) [11, 12] posits that efficacy plays a mediating role in the relationship between risk perception and response to the fear appeal message. Based on the interaction between risk perception and perceived efficacy, Witte (1992) identifies two possible outcomes even with high perceived risk (High risk-High efficacy and High risk-Low efficacy) based on the available risk reduction measures. One of the implications of this is recognition that greater fear does not necessarily lead to greater message acceptance, but can perversely cause message rejection, a possibility not acknowledged by HBM. Therefore, identifying the risk-efficacy interaction is relevant in tailoring the communication strategy aimed at improving health response behaviour. Moreover, according to EPPM, if the individual perceives low risk, then there is no motivation to adopt behavioural change even if the individuals have high efficacy.

The HBM and EPPM frameworks have been used extensively to assess and predict the effect of health messaging on the recommended behavioural responses. Pre-COVID studies have used the EPPM in the context of various health issues such as cardiovascular diseases, hygienic behavior, public health emergency response, teen pregnancy, smoking, vaccination, and HIV/AIDS, among others [19–23]; and also specifically relating to vaccine confidence [24, 25].

Studies within the COVID context are fast emerging using the EPPM framework [26–29] or the HBM framework [30]. However, these studies relate primarily to non-vaccine behaviour. Exceptions are Chu and [31] in the US context and [28] in the context of China which used the EPPM and HBM frameworks respectively to assess COVID19 vaccine behaviour. [32] has identified the correlates of vaccine hesitancy in Australia, without the use of a specific theoretical framework. The authors have not been able identify a study in the South African context on COVID19 vaccine intention.

[13] has highlighted the scarcity of empirical studies that compare the different health behaviour theories in their analysis, with most studies choosing to stick to one selected theory as the framework. This study sees value in comparing the HBM and EPPM. Both these theories are based on fear assessment as the major motivator of behavioural change [13] and as such are suited to the pandemic context.

The objective of this study is to assess the level of COVID19 vaccine hesitancy in South Africa, identify the socio-economic patterns in vaccine hesitancy and to develop a targeted health communication strategy based on the HBM and EPPM models in order to improve vaccine acceptance.

2. Data

The study uses primarily the fourth wave of the National Income Dynamics Study - Coronavirus Rapid Mobile Survey (NIDS-CRAM 2021) survey [33]. The NIDS-CRAM survey is a special follow up with a subsample of adults from households in Wave 5 of the National Income Dynamics Study (NIDS) run by Southern Africa Labour and Development Research Unit (SALDRU). The NIDS is South Africa's first nationally representative household level panel survey undertaken approximately in two-year intervals between 2008 and 2017, covering a wide range of socio-economic, health, labour and household related information. The NIDS-CRAM survey is designed to be nationally representative and despite the lower sample size (compared to NIDS) remains the best available source of quantitative information on a national scale to assess the socio-economic impact of the corona virus pandemic in South Africa. More detailed technical information on NIDS-CRAM surveys is provided by [34–37].

The fourth wave of the NIDS-CRAM has a sample, covering complete questionnaire information, for 5629 individuals. The fourth wave of the NIDS-CRAM survey was conducted over the months of February (96%) and March (4%) 2021. Therefore, the questions were administered under adjusted alert level 3 (Feb 2–28 Feb 2021, when curfew restrictions were imposed and businesses had to adhere to regulations on the maximum number of persons on their premises) and adjusted alert level 1 (March 2021, when most normal activity was allowed to resume with precautions and health guidelines being followed) lockdown conditions.

The wave 4 of NIDS-CRAM introduced a question on vaccine intention “To what extent do you agree or disagree with the statement: If a vaccine for COVID-19 were available, I would get it?”, allowing for response on a four-point scale of “strongly agree, somewhat agree, somewhat disagree and strongly disagree”. A further vaccine related question included is “What is the main reason why you would not take a vaccine for COVID-19?”.

The key risk perception variable is derived from the NIDS-CRAM questionnaire using the ‘yes’ or ‘no’ response to the question ‘Do you think you are likely to get the corona virus?’. The limitation here is that the risk question gives an indication of vulnerability or susceptibility, but not of severity of risk. The study therefore uses two proxy variables to control for the severity of risk based on the emerging evidence that older age groups as well as those with pre-existing chronic illnesses have higher risk of severe COVID symptoms, hospitalization as well as mortality rates compared to younger age groups [38, 39]. Therefore, the first proxy for severity (mortality threat) incorporated in the model is age (measured in years) and the second proxy is obtained by using the ‘yes’ or ‘no’ response to the question “Do you have any of these chronic conditions (you don’t have to tell us which one): HIV, TB, lung condition, heart condition or diabetes?”.

The efficacy variable is sourced from the ‘yes’ or ‘no’ response to the question “Can you avoid getting Coronavirus?” The key limitation relating to this variable is that the survey instrument does not afford an opportunity to differentiate between NPI and vaccine related efficacy separately. Given that at the time of the survey vaccines were not yet widely available in South Africa, it is more likely that the responses relate to NPI rather than vaccines. Therefore, we additionally make use of the question “What is the main reason why you would not take a vaccine for COVID-19?”, to create a vaccine specific efficacy variable that takes the value one if ineffectiveness of vaccine is not a response to the question. The NPI efficacy and vaccine efficacy variables are interacted to create a combined measure of efficacy.

Lastly, barriers to behavioural change are an important consideration of HBM. One of the barriers is the lack of information. In order to assess the COVID19 related awareness of respondents, a binary variable is constructed which takes the value 1 if the respondent is aware of the three most important symptoms of infection (cough, breathlessness and fever). The assumption made is that a person who is fully aware of the COVID19 symptoms would also be aware of the available information related to vaccine. A further point to note is that the information on knowledge of COVID symptoms was collected in wave 1 during May/June 2020 and as such is limited by the time lapse between the survey waves. More generally, education is also considered as a proxy for awareness.

Apart from awareness, the feasibility of adopting the protective measure is also proxied with household per capita income based on the argument that income reduces the barriers to behavioural change. The household income variable has a high proportion of missing information in the survey data. As such, rand value responses to household income variable have been supplemented with the median value of the income bracket responses. This approach can however distort the income distribution and therefore following [40] we reweight those who provide rand amounts using the inverse of the probability that an individual will report a rand amount in that bracket. Although this approach does not account for observations that have both the rand value and income bracket information missing, we are able to retain 5272 out of 5629 observations. Further, alternate models are estimated where socio-economic status is controlled for by including other variables such as recent experience of hunger in the household, presence of grant recipients in the household, and electrified dwelling as additional checks.

Because individual responses emerge from a complex interaction of different social, cultural, political and personal factors in vaccine decision [41], additional socio-economic variables such as sex(male), race (black African), partnered, location (urban) and religiosity are incorporated to get a clearer picture of the range of possible predictors about vaccine intention.

Further limitation of the data used is that it is largely self-reported and therefore hard to assert that there was no strategic bias in response. Therefore, the study acknowledges the limitation that it may be susceptible to hypothetical and strategic bias [42] especially for key questions like vaccine intention and non-pharmaceutical protective behaviour.

3. Preliminary Analysis

Based on the responses to the question on vaccine intention, 55% of the population are seen to have strong acceptance of the vaccine (Fig. 1). A further 16% are found to accept the vaccine, but with lower certainty. Strong vaccine rejection is indicated by 16%, with a further 7% tending to less strongly reject the vaccine. In addition, 6% did not respond to the question as they were unsure, which may be construed as indicating uncertainty regarding vaccine intention.

Converting the four-scale response to binary variable by combining ‘strongly agree’ with ‘somewhat agree’ to define vaccine acceptance; and ‘strongly disagree’ with ‘somewhat disagree’ as well as ‘don’t know’, to derive the vaccine hesitancy. Based on this definition, vaccine hesitancy is calculated as being 29.16%

(with 95% confidence interval of 28%-30%). This is a significant proportion of population and raises concern regarding the success of achieving herd immunity through vaccination.

Table 1
Summary statistics of Risk and Efficacy, by severity/mortality risk

Variable	**Mean**	**Age: 60 years and above**	**Age: below 60 years**	**t-test**	**chronic**	**no chronic**	**t-test**
Risk	0.450	0.398	0.458	*	0.481	0.444	-
	(0.498)	(0.490)	(0.498)		(0.500)	(0.497)	
Efficacy	0.824	0.829	0.823	-	0.850	0.818	-
	(0.381)	(0.376)	(0.382)		(0.357)	(0.386)	
High Risk, High efficacy	0.305	0.216	0.321	***	0.339	0.297	-
	(0.460)	(0.412)	(0.467)		(0.474)	(0.457)	
High Risk, Low efficacy	0.064	0.032	0.070	***	0.055	0.066	-
	(0.245)	(0.176)	(0.255)		(0.227)	(0.248)	
Low -risk	0.550	0.602	0.542	*	0.519	0.556	-
	(0.498)	(0.490)	(0.498)		(0.500)	(0.497)	
Low risk, Low efficacy	0.080	0.077	0.081	-	0.070	0.082	-
	(0.077)	(0.266)	(0.273)		(0.255)	(0.275)	
Low risk, High efficacy	0.376	0.343	0.382	-	0.346	0.382	-
	(0.484)	(0.475)	(0.486)		(0.476)	(0.486)	
Source: NIDS-CRAM wave 4, weighted. Standard errors in parentheses, *** p < 0.01, ** p < 0.05, * p < 0.1							

Considering the risk and efficacy variables, it is clear that the risk perception (45%) is substantially lower than efficacy (82%) (Table 1). While 45% perceived the risk of COVID19 infection, a higher proportion of 55% did not. Age and co-morbidities are considered as two risk factors that increase the probability of severe symptoms, hospitalization and mortality. As such we examine whether risk and efficacy variables are different for those in these categories. The average risk perception is higher for those below sixty years of age, explained by the elderly more likely to be staying home with lower external exposure. The corollary of this is that higher proportion of elderly perceive low risk compared to the younger group. A significantly lower proportion of the elderly are in the responsible and denial categories compared to those below sixty years. Within the EPPM risk-efficacy categories, the highest proportion is of low risk-low efficacy (indifference) group (48.3%). Responsive group is estimated at 39.5% of the adult population. No significant difference is found in the risk and efficacy levels of those suffering from chronic conditions and others.

4. Assessing Vaccine Hesitancy

Figure 2 presents average vaccine hesitancy levels across sex, race and education attainment. While females in the sample had on average higher vaccine hesitancy (31%) compared to males (27%), the difference is significant at 95% confidence level. What is clearly evident at even 99% confidence level is the higher vaccine hesitancy among non-black population (35%), compared to the black African population (239%). Those with tertiary education is seen to have significantly lower hesitancy (26%) compared to those with below tertiary education (31%). Geographical location is found to be also a significant differentiating factor with vaccine hesitancy found to be higher in urban areas (30%) compared to rural areas (27%). Individuals who reported chronic illness have on an average lower (23%) vaccine hesitancy compared to those who did not report chronic illness (30%).

Considering the association between health behaviour variables and vaccine hesitancy, risk perception is seen to be more significant than efficacy as a differentiating variable of vaccine hesitancy (Fig. 3). Individuals with high-risk perception have statistically lower vaccine hesitancy (26%) compared to those with low-risk perception (31%). Statistically significant differences are evident in the hesitancy across the efficacy groups as wells as the risk-efficacy interaction groups (responsive and denial).

Figure 4 highlights significant difference between the vaccine hesitancy rates of urban and rural areas, those who reported chronic illness and those who did not, those who had full information and those who did not, who experienced hunger and who did not. While these findings are relevant and points to possible predictors, it is possible that there may be confounding factor like income behind some of these variables. For instance, poverty and hunger is higher in rural areas in South Africa. Thus, it is important to undertake a multivariate analysis before drawing firm conclusions on the predictors of vaccine hesitancy.

6. Socio-economic Inequality In Vaccine Hesitancy, Risk And Efficacy

This section uses concentration index to assess the socio-economic inequality in the prevalence of vaccine hesitancy, as well as the risk and efficacy parameters along the income, age and education distributions. As vaccine hesitancy, risk perception and efficacy variables are all binary, Erreygers-corrected concentration index [43] is used to assess their socio-economic inequality.

While income-based inequality is not evident for vaccine hesitancy, it is clear that income plays a key role when it comes to risk and efficacy (Table 2). Vaccine hesitancy is negative and significant along age, pointing to higher acceptance among the elderly. The higher hesitancy concentration among the young could be related to the perceived lower severity of the infection related morbidity and mortality among the younger age groups [44, 45].

Risk perception is significantly higher among those with higher income. Similar results have been reported by [30] based on wave 1 and 2 of the NIDS-CRAM. Our results show that this pattern is sustained after a year. As expected, risk perception has a significant positive concentration along the age distribution indicating higher risk perception among the older individuals (Table 2). This is not surprising considering the available information that age increases severity of COVID illness, the risk of hospitalisation and higher COVID infection related mortality rate [38, 39]. This is related to the results observed with regards to vaccine hesitancy, and points to the mediating role of risk perception in leading to the higher vaccine hesitancy among younger age groups.

Both risk perception and efficacy are found to be pro-education. The risk-efficacy interaction variables are led by risk in terms of their concentration patterns. 'Responsive' (high risk-high efficacy) and 'Denial' (high risk-low efficacy) are both pro-rich, aligned with the results of risk perception. The low risk category (combination of low-risk-high efficacy, and low risk-low efficacy groups) are pro-poor. Low-risk are also pro-young and pro-low education.

The findings indicate that although vaccine hesitancy is not concentrated along the income or education distribution, they can nevertheless play a role through mediating factors like risk perception which have definite concentration along income, age and education distributions.

Table 2
Erreygers concentration index of vaccine hesitancy, risk and efficiacy

CI	Vaccine hesitancy	Risk	Efficacy	Responsive (High risk-high efficacy)	Denial (High risk-Low efficacy)	Low risk
Income	-0.017	0.223***	-0.03	0.143***	0.043***	-0.223***
	(0.031)	(0.035)	(0.024)	(0.030)	(0.016)	(0.35)
Age	-0.121***	0.111***	-0.003	0.023	-0.014	-0.111***
	(0.023)	(0.026)	(0.017)	(0.023)	(0.009)	(0.026)
Education	-0.018	0.132***	0.045***	0.114***	0.029**	-0.133***
	(0.023)	(0.027)	(0.018)	(0.025)	(0.011)	(0.027)
Standard errors in parentheses, *** p < 0.01, ** p < 0.05, * p < 0.1						

7. Multivariate Analysis

The descriptive statistics of the key socio-economic characteristics of the sample for the multivariate regression indicate resonance with national statistics (Table 3).

Table 3: Summary statistics of the Study Sample

Variable	Obs	Mean	Std. Dev.	Min	Max
Age, years (Risk Severity risk 1)	4,440	40.47	15.04	18	90
Chronic illness (Risk Severity 2)	4,440	0.168	0.374	0	1
Well-informed (Barrier 1)	4,440	0.096	0.295	0	1
Household per capita income, Rands (Barrier 2)	4,440	2854	6135	0	150000
Education, years	4,440	11.52	3.729	0	22
African	4,440	0.782	0.413	0	1
Male	4,440	0.482	0.500	0	1
Married/with partner	4,440	0.479	0.500	0	1
Urban	4,440	0.760	0.427	0	1
Informal_dwelling	4,324	0.117	0.322	0	1
Electricity	4,440	0.946	0.226	0	1
Experienced Hunger	4,440	0.164	0.370	0	1
Employed	4,440	0.497	0.500	0	1
Social Grant recipient	4,440	0.353	0.478	0	1
Religious	4,440	0.913	0.282	0	1

Source: NIDS-CRAM weighted. # All variables except age, education and income are binary

The results of logit regressions highlight the role of risk and efficacy in driving vaccine hesitancy while controlling for other pertinent predictors (Table 4). Columns 1 - 3 and 4-6 are based on the HBM, and the EPPM respectively. Various specifications are estimated using log of per capital income, income quintiles and non-financial proxies for socio-economic status (hunger in household, household with electricity, grant recipient in household).

Table 4: Logit regression results: Dependent variable, Vaccine Hesitancy

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	HBM	HBM	HBM	EPPM	EPPM	EPPM
Risk perception	-0.265**	-0.268**	-0.271**			
	(0.133)	(0.133)	(0.133)			
Efficacy	-1.260***	-1.260***	-1.248***			
	(0.155)	(0.154)	(0.153)			
Low risk^				0.429***	0.433***	0.429***
				(0.125)	(0.124)	(0.124)
Denial^				1.061***	1.068***	1.052***
				(0.230)	(0.230)	(0.231)
Severity 1(Age)	-0.0251***	-0.0260***	-0.0262***	-0.0216***	-0.0220***	-0.0221***
	(0.00539)	(0.00531)	(0.00534)	(0.00472)	(0.00469)	(0.00469)
Severity 2 (chronic)	-0.155	-0.153	-0.158	-0.263*	-0.267*	-0.241
	(0.175)	(0.175)	(0.176)	(0.155)	(0.155)	(0.156)
Barrier 1 (Information)	-0.287	-0.330	-0.338	-0.431**	-0.459**	-0.469**
	(0.217)	(0.215)	(0.218)	(0.213)	(0.212)	(0.213)
Barrier 2 (education)	-0.0442**	-0.0511***	-0.0499***	-0.0370**	-0.0414**	-0.0437**
	(0.0191)	(0.0196)	(0.0190)	(0.0177)	(0.0184)	(0.0176)
Barrier 3 (log PC HH Income)	-0.071*			-0.0694*		
	(0.0418)			(0.0389)		
2. PC HH Income _Q2		0.036			0.068	
		(0.177)			(0.28)	
3. PC HH Income _Q3		-0.348			-0.271	
		(0.223)			(0.194)	
4. PC HH Income _Q4		-0.101			-0.0545	
		(0.201)			(0.178)	

5. PC HH Income _Q5		0.0524			0.0118	
		(0.204)			(0.191)	
Hunger			-0.216			-0.212
			(0.167)			(0.149)
Electricity			0.135			-0.109
			(0.302)			(0.259)
Grant receiving Household			0.210	0.136	0.144	0.154
			(0.132)	(0.117)	(0.118)	(0.118)
African	-0.817***	-0.768***	-0.782***	-0.776***	-0.743***	-0.718***
	(0.216)	(0.214)	(0.215)	(0.196)	(0.194)	(0.194)
NPI behaviour	-0.114**	-0.117**	-0.119**	-0.140***	-0.142***	-0.148***
	(0.0578)	(0.0577)	(0.0577)	(0.0512)	(0.0513)	(0.0511)
male	-0.218*	-0.240*	-0.216*	-0.169	-0.182	-0.174
	(0.125)	(0.126)	(0.124)	(0.114)	(0.115)	(0.113)
Married/Partnered	0.214	0.205	0.228*	0.251**	0.250**	0.237**
	(0.132)	(0.131)	(0.133)	(0.120)	(0.119)	(0.120)
Employed	0.196	0.165	0.178	0.0406	0.0202	-0.0193
	(0.130)	(0.133)	(0.131)	(0.121)	(0.122)	(0.120)
Religious	-0.0867	-0.0657	-0.0872	0.00923	0.0305	0.0226
	(0.240)	(0.240)	(0.239)	(0.223)	(0.226)	(0.222)
Province controls	yes	yes	yes	yes	yes	yes
Constant	3.037***	2.529***	2.420***	1.544**	1.021*	1.235**
	(0.635)	(0.579)	(0.676)	(0.601)	(0.556)	(0.613)
Wald chi2	138.57**	158.31***	158.14***	115.46***	122.23***	115.96***
Observations	4,264	4,264	4,235	4,441	4,441	4,440

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

^ the benchmark variable is Responsive (High risk-high efficacy)

The results of HBM specifications are consistent in underscoring the significance of risk perception of infection and efficacy as negative predictors of vaccine hesitancy. The EPPM results also indicate that individuals who perceive lower vulnerability to infection are more likely to be hesitant about accepting vaccine compared to the responsive (high risk and high efficacy) group.

The results indicate that, compared to responsive individuals, the low-risk individuals are more likely to be hesitant regarding the vaccine. We also see a significant difference between the vaccine intention of the 'responsive' and the 'denial' groups. This once again points to risk perception as being the driving factor, with no clear mediating role of efficacy being apparent.

Therefore, EPPM estimations further highlight the mediating role of efficacy, where the denial group (high risk-low efficacy) has a significantly higher vaccine hesitancy in relation to the responsive group. These results are insightful and suggest that it is important to accompany risk messaging with efficacy related communication to encourage individuals to accept vaccination.

Severity of risk, proxied through age has a significant negative association with vaccine hesitancy in both HBM and EPPM estimations. The second proxy for severity, chronic illness, is also significant in the EPPM model. The indication therefore is that in addition to vulnerability to infection, vaccine intentions are strongly driven by the perceived severity of risk as well.

Income, education and information availability are incorporated in the model as measures of barriers to adoption of health response. Education is likely to be correlated with both income and Covid related information, as such its significance is indicative of the key role that awareness plays in vaccine intentions. Similarly, the variable relating to information regarding COVID is negative (although significant only in the EPPM estimations) pointing to the need for creating more awareness and education around vaccines to reduce hesitancy. The income variable is rather weak and does not come out strong in the estimations. This however could be due to its strong correlation with some of the other variables in the model like education. The other proxies included to control for socio-economic status like experience of hunger, social grant receipt, and electrified dwelling also do not give any strong indications on their role in driving vaccine hesitancy. However, there is still the possibility that socio-economic status acts via risk perception and efficacy. This is explored further in section 10.

The positive association between adoption of NPI behaviour (measured as number of non-pharmaceutical preventive behaviour adopted) and vaccination is evident in both the HBM and EPPM models. There are other interesting socio-economic predictors of vaccine intention revealed through both HBM and EPPM estimations. Black Africans have significantly lower vaccine hesitancy compared to other race groups. Being married or having a partner is found to increase vaccine hesitancy significantly. This finding is contrary to expectations as being married is found in literature to have protective effect on health behaviour [46]. However, there have been studies [47] that cite negative relationship between vaccination and being married (or in a steady relationship). The result that males are on average less hesitant than females is consistent with the finding by [32] in the Australian context.

In order to remove any bias caused by the construct of the efficacy variable, we re-estimate the HBM and EPPM specifications excluding the observations where only vaccine hesitancy drives the efficacy variable. In other words, we drop observations where vaccine ineffectiveness takes the value one and the general efficacy variable is one. This ensures that there is no definitional relationship between the efficacy variable and the dependent variable of vaccine hesitancy. The results from this restricted estimation are given in appendix (table A1) and validates the results in Table 5.

As a further robustness check we also present results of ordinal logit regressions, where the dependent variable of vaccine intention is used in its original form with four response categories. The marginal effects of the regression relating to the key risk and efficacy variables for each of the four outcomes are presented in table 5.

The results are consistent with the logit regression with regards to risk and efficacy for the HBM model, and the risk-efficacy interaction variables (denial and low risk) for the EPPM model. The findings hold that risk perception, through the mediation of efficacy is driving vaccine intentions. The severity of risk proxied by age is significant predictor as in the logit model. There are however some deviations from the logit model in relation to chronic illness with it being significant in HBM but not in EPPM estimation. Education on the other hand, is significant only in the EPPM model for the ordinal estimation.

Table 5 Ordinal logit, marginal effects: Dependent variable, Vaccine Intention.

HBM	High Risk	High Efficacy	Severity-age	Severity-Chronic illness	Barrier-Education	Barrier-income	Barrier-information
Strongly accept vaccine	0.050**	0.197***	0.007***	0.070**	0.003	0.016	0.047
	(0.024)	(0.031)	(0.001)	(0.032)	(0.003)	(0.011)	(0.045)
Somewhat accept vaccine	-0.012**	-0.048***	-0.002***	-0.017**	-0.001	-0.004	-0.011
	(0.005)	(0.008)	(0.000)	(0.008)	(0.001)	(0.003)	(0.011)
Somewhat reject vaccine	-0.009**	-0.038***	-0.001***	-0.014**	-0.001	-0.003	-0.010
	(0.004)	(0.009)	(0.000)	(0.006)	(0.001)	(0.002)	(0.009)
Strongly reject vaccine	-0.028**	-0.111***	-0.004***	-0.039**	-0.002	-0.009	-0.026
	(0.016)	(0.024)	(0.001)	(0.020)	(0.002)	(0.006)	(0.025)
EPPM	Denial ^	Low risk^	Severity-age	Severity-Chronic illness	Barrier-Education	Barrier-income	Barrier-information
Strongly accept vaccine	-0.173***	-0.066***	0.007***	0.055	0.008**	0.016	0.039
	(0.044)	(0.024)	(0.001)	(0.036)	(0.002)	(0.011)	(0.044)
Somewhat accept vaccine	0.040***	0.016***	-0.002***	-0.013	-0.002**	-0.004	-0.010
	(0.011)	(0.005)	(0.000)	(0.009)	(0.000)	(0.003)	(0.011)
Somewhat reject vaccine	0.035***	0.013***	-0.002***	-0.012	-0.002**	-0.003	-0.008
	(0.003)	(0.006)	(0.000)	(0.008)	(0.000)	(0.002)	(0.009)
Strongly reject vaccine	0.037***	0.098***	-0.004***	-0.030	-0.005**	-0.009	-0.022
	(0.018)	(0.025)	(0.001)	(0.020)	(0.000)	(0.006)	(0.024)

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1, ^Benchmark category is responsive (high risk-high efficacy)

8. Reasons For Vaccine Hesitancy

In this section we look at reasons reported by respondents for vaccine hesitancy. The analysis is based on the response to the question in the survey “What is the main reason why you would not take a vaccine for COVID-19?”. Among the reasons cited for vaccine hesitancy, the highest proportion cited concerns regarding side-effects of vaccines (30%) (Fig. 5). This is not surprising considering the lack of public information on vaccine trials as well as emerging media reports on possible serious side-effects of certain vaccines like blood-clotting [48].

Concerns regarding the side-effects of vaccine aside, almost 19% of those who indicated unwillingness to accept vaccine pointed to ineffectiveness of vaccines as a reason for vaccine hesitancy. The mixed messaging coming through media on the efficacy of vaccines as well as their uncertainty regarding the usefulness against the new COVID strains are contributing to the concerns regarding ineffectiveness of vaccine. The concerns regarding side effects and ineffectiveness (jointly accounting for 49%) are specific to COVID19 vaccines and therefore needs to be addressed with specific information on COVID19 vaccines. A further 2% indicated lack of trust in vaccines and government. The lack of clarity in communication and unavailability of information on vaccines are clearly contributing to vaccine hesitancy.

General anti-vaccine stance, that extends beyond COVID specific vaccine inhibition accounted for nearly 15% of individuals who indicated vaccine hesitancy. This category of individuals will need to be addressed with information beyond COVID-specific vaccine. The approach taken would have to be broader, but nevertheless COVID specific information will also be useful in generating awareness on vaccine efficacy.

The response efficacy related factors aside, it is clear from that a significant section of individuals do not believe that COVID poses a significant risk (10%). The need to address this category with risk messaging is clearly evident. Further a prominent reason cited within the “other” category is “conflicting messages from media / on social media".

The reasons for vaccine hesitancy therefore highlight the need to improve communication regarding efficacy of vaccines as well as to create further awareness on the risks associated with COVID through risk messaging.

Table 6
Erreygers-corrected Concentration index for vaccine hesitancy reasons

CI	Side-effects	Anti-vaccination	Ineffective	No COVID risk
income	-0.069	-0.006	0.117**	0.016
SE	(0.063)	(0.056)	(0.051)	(0.034)
age	0.050	-0.035	-0.138**	0.030
SE	(0.053)	(0.043)	(0.049)	(0.024)
education	0.010	-0.062	0.101*	-0.024
SE	(0.048)	(0.045)	(0.046)	(0.029)
Robust standard errors in parentheses, *** p < 0.01, ** p < 0.05, * p < 0.1				

There is not much indication of concentration of the various reasons for vaccine hesitancy along the income, age and education distribution, with the exception of ‘ineffective’ as a reason (Table 6). ‘Ineffective’ is found to be pro-young and pro-educated. The scepticism regarding the efficacy of vaccination needs to be communicated within these socio-economic groups through more transparent sharing of information based on scientific research.

9. Comparison With Non-pharmaceutical Intervention (Npi)

Studies on the adoption of NPI in South Africa indicate a high level of uptake, with close to 100% of the population indicating some form of changed behaviour as a protective response to COVID. This is much higher than the vaccine acceptance currently observed. It is not surprising that inhibitions regarding vaccines are higher than NPI, and can be attributed to possible secondary harms through vaccination. Also, unlike vaccination, some NPI measures like wearing of facemask and limits on social gatherings have been made mandatory via government regulation. This implies that adoption of these mandatory NPI measures may be less driven by individual perception of risk and efficacy.

The results of the seemingly unrelated regressions (Tables A2 and A3) validate this where the role of efficacy is less evident for NPI for the most popular non-pharmaceutical preventive behaviour (the use of facemask) in South Africa [30]. Efficacy however has a significant association with the use of sanitizers and hand hygiene behaviour. Similarly, the mediating role of efficacy is not strongly evident for facemask use, but is significant for the practise of hand hygiene and the use of sanitizers. The indications are that the government regulation making facemask use mandatory has impacted on behaviour and therefore it is less driven by individual discretion which is influenced by efficacy.

The role of risk perception on the other hand, is found to have a significant association across all forms of non-pharmaceutical protective behaviour as well as vaccine intention (Tables A2, A3 and Table 5). The low-risk group has significantly lower probability of adopting the most popular forms of NPI indicating that NPI behaviour is driven primarily through risk assessment.

10. Targeted Communication

The multivariate analysis of predictors of vaccine hesitancy has identified denial and low-risk perception (low risk-low efficacy and low risk- high efficacy) categories as positive predictors of vaccine hesitancy. Therefore, it is important to target foremost these groups for health communication based on not just fear appeal but also efficacy messaging. This requires identifying the socio economic and demographic characteristics of these groups. For this purpose, the study next undertakes a multinomial logit regression, where the base category is the responsive (high risk-high efficacy) category (Table 7). It must be flagged here that the construct of the risk categories here is based on risk perception and not severity of risk.

Table 7: Multinomial logit regression: Base regression, Responsive category.

VARIABLES	Denial^	Low risk^
Age	-0.0152	-0.105***
	(0.0419)	(0.0227)
Age squared	1.77e-05	0.00109***
	(0.000428)	(0.000249)
Education (years)	0.00383	-0.0445**
	(0.0376)	(0.0175)
African	-0.637*	0.107
	(0.368)	(0.222)
Well informed	0.0925	-0.290
	(0.312)	(0.192)
Male	0.313	-0.00667
	(0.225)	(0.118)
Married	-0.104	-0.304**
	(0.229)	(0.122)
Urban	0.190	-0.0475
	(0.323)	(0.126)
Informal_dwelling	-0.0408	-0.260
	(0.410)	(0.196)
Electricity	0.00573	-0.474*
	(0.711)	(0.262)
Employed	-0.203	-0.665***
	(0.267)	(0.132)
Household income	-0.0104	-0.103**
	(0.0839)	(0.0438)
Grant recipient	0.283	-0.145
	(0.256)	(0.121)
Religious	1.157**	-0.165
	(0.529)	(0.228)

Chronic illness	-0.210	-0.242
	(0.270)	(0.148)
Province control	yes	yes
Constant	-2.328	4.920***
	(1.839)	(0.735)
Wald chi2(46)	206.46***	206.46***
Observations	4,179	4,179

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

^ Base regression: Responsive (High risk-high efficacy)

Compared to the benchmark category (responsive), higher age is likely to decrease the probability of belonging in the low-risk group (Table 7). However, the non-linear relationship indicates that the elderly is also likely to belong to the low-risk group, explained due to the fact that they are mostly home-bound and not exposed to external interactions. Education is also likely to decrease the probability of belonging in the low-risk perception group, vis-à-vis the responsive group. Being married (or with a partner) as well as being employed has a similar effect of reducing the probability of being in the low-risk perception group. Higher socio-economic status (as indicated by income, being employed and electrified dwelling) also decreases the probability of being in the low-risk perception group.

There are not many significant identifiers of the denial group (high risk-low efficacy) from the responsive group (high risk-high efficacy). While black African have lower probability of being in the denial category compared to responsive category, those who consider religion to be important are more likely to be in the denial category.

These results indicate that targeting the young, the less informed, low-income individuals, those without partners, and the unemployed through risk messaging. On the other hand, non-blacks and the religious need to be targeted for protective danger control and education on solutions to the threat of the pandemic. Over 91 percent report that religion plays an important role in their life, and as such our results show that efficacy communication through religious leaders and institutions would be effective.

Our findings show that unless efficacy of the available response behaviour (NPI and vaccine) is communicated, enhanced risk perception alone will not result in appropriate behavioural response (including vaccine acceptance).

11. Summary And Policy Implications

Based on the vaccine intentions of the respondents of NIDS-CRAM survey, only 55% are fully accepting of the vaccine, while a further 16% are moderately accepting of vaccines. Combining these two groups, vaccine acceptance is estimated at 70.8% in South Africa. Correspondingly, vaccine hesitancy in South Africa is estimated at 29.2% (with 95% confidence interval of 28%-30%) for the general adult public. This is significantly high and raises concern regarding the effectiveness of vaccination programme once vaccines become widely available to the public. This is especially when considering that vaccines are not 100% effective, and for vaccine effectiveness of 60%, vaccine coverage of 100% is required to achieve control of the virus (Bartsch et al 2020). These results relate to information collected in February 2021 and needs to be monitored closely going forward.

Comparing the findings of this study with the meta-analysis by [6], vaccine hesitancy in South Africa is higher than countries like Ecuador, Malaysia, Indonesia and China; but lower than countries like Kuwait, Jordan, Italy, Russia, Poland, US, and France.

Vaccine acceptance in South Africa is substantially lower than the non-pharmaceutical behavioural changes undertaken as protective measure against COVID19. Despite the sustained efforts required for NPI based preventive strategy, the concerns regarding the perceived dangers of secondary harm of pharmaceutical interventions compared to NPIs is an emerging explanation for this. Another possible explanation is that some non-pharmaceutical measures like the use of face mask and limits to social gathering have been made mandatory under government regulations, whereas vaccine acceptance is considered to be left to individual discretion. Nonetheless, the results indicate that individuals who take NPI seriously are also more likely to accept vaccination.

There are significant differences across socio-economic variables in vaccine hesitancy. Age has emerged as a significant predictor of vaccine hesitancy with younger individuals more likely to be against vaccine acceptance. This is not surprising given the lower risk perception among the young with regards to the severity of COVID19. Similarly, those reporting chronic illness also have lower hesitancy compared to their healthier counterparts.

Non-black African population group has significantly high vaccine hesitancy compared to black Africans. Males on average have lower hesitancy compared to females. Unmarried/unpartnered individuals are found to have higher hesitancy. Education on the other hand is found to reduce hesitancy.

In addition, health behaviour models offer important predictors of vaccine intentions. Risk perception (both vulnerability and severity) is a key driving factor along with efficacy. This study validates the argument by [11, 23] that efficacy plays an important mediating role in the relationship between risk perception and the associated behavioural response. The group that was seen to be most accepting of vaccines are those that perceive high risk as well as high efficacy. Doubts regarding the response efficacy of vaccination however has emerged as the deterring reason against vaccine acceptance. From a communication perspective, it is imperative to continue risk messaging, hand in hand with clearer information on the efficacy of the vaccines.

The fear messaging needs to be targeted at younger age population who perceive the lowest risk. Those who are less informed on COVID19 are also found to be those who perceive low risk; therefore, this reinforces the need to have in place a communication plan to educate and create awareness on the pandemic. However, as highlighted by [49] excessive fear messaging without efficacy-related messaging can lead to mental health issues. Therefore, efficacy messaging cannot be ignored. Considering that 91% of South Africans consider religion to be important, and the finding that religious individuals are more likely to belong to the denial (high risk-low efficacy) group, a recommendation emerging is the use of religious leaders and institutions for efficacy messaging.

The need for efficacy messaging also is showcased by an analysis of the reasons that were cited for vaccine hesitation. These include primarily the possible negative side-effects, and the ineffectiveness of vaccine. While the risk of blood clots associated in particular with AstraZaneca and Johnson& Johnson vaccines has grabbed headlines, the risk of the vaccine vis a vis more accepted pharmaceutical practices like the use of contraceptive pills is considered to be lower [50]. This shows that there is a need to make available more information from the scientific studies on the possible side-effects and effectiveness that would allow individuals to make more informed judgements. The lack of transparency in this regard is contributing substantially to vaccine hesitancy and there is a clear need for better communication around this.

General anti-vaccine stance, that extends beyond COVID specific vaccine inhibition accounted for nearly 15% of individuals who indicated vaccine hesitancy. This category of individuals will need to be addressed with information beyond COVID-specific vaccine. The approach taken would have to be broader, but nevertheless COVID specific information will also be useful in generating awareness on vaccine efficacy.

Table 8: Communication strategy recommendations

Responsive: People are educated about risk, believe in efficacy and respond by taking protective action. 40% of population are responsive. Vaccine hesitancy is 26%. Profile: Older, educated, married, well-informed Strategy: Provide calls to vaccination and make vaccination available. Provide clear information on COVID19 vaccine side effects and effectiveness	Denial: People are aware of the risks but feel helpless to respond effectively. 7% of population fall in this category. Vaccine hesitancy is 27%. Profile: Non-black, religious Strategy: Less focus on fear messaging and more on protective danger control through educating about solutions Provide clear information on COVID19 vaccine side effects and effectiveness
Low risk: Due to the low risk perception, people do not enter into efficacy assessment. 52.6% of population fall in this category Vaccine hesitancy is highest at 31%. Profile: Young, low education, single status, less informed, low income Strategy: Educate through risk and fear messaging, followed by risk and protective danger control through awareness about solutions. Provide clear information on COVID19 vaccine side effects and effectiveness	

Widening vaccine acceptance requires a three-pronged health communication strategy being put in place that targets fear messaging to the young, uneducated, less informed, lower income individuals; efficacy messaging to non-black and religious individuals; call to action among older, educated and well-informed individuals. The targeted communication aside summarized in Table 8, there is an over-arching need to provide research-based information on the side-effects and effectiveness of COVID 19 vaccines across the board.

Declarations

Ethics approval and consent to participate: Ethics approval for the NIDS-CRAM Survey was granted by the Commerce Faculty Ethics Committee of the University of Cape Town and the Research Ethics Committee: Social, Behavioral and Education Research, of the University of Stellenbosch.

Consent for publication: Not applicable

Availability of data and materials: The data is available from http://www.nids.uct.ac.za/nids-cram/data-access

Competing interests: The authors have declared that no competing interests exist.

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Figures

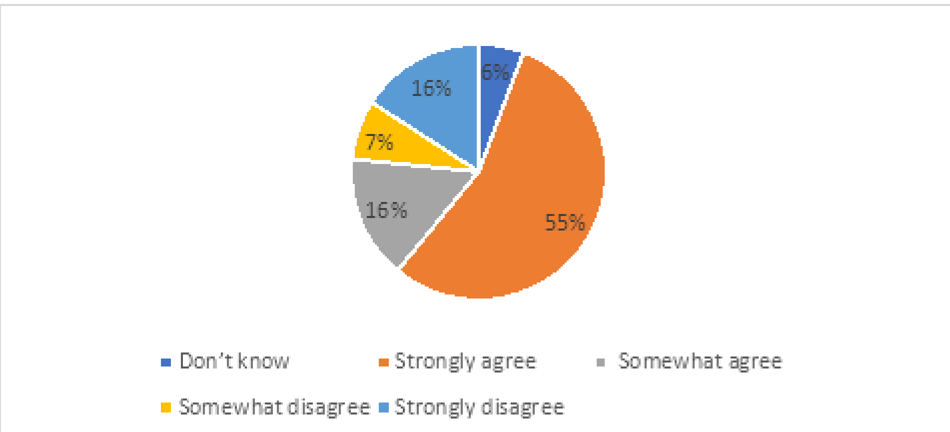

Figure 1

If a vaccine for COVID-19 were available, I would get it? Source: NIDS-CRAM wave 4. n=5613, weighted.

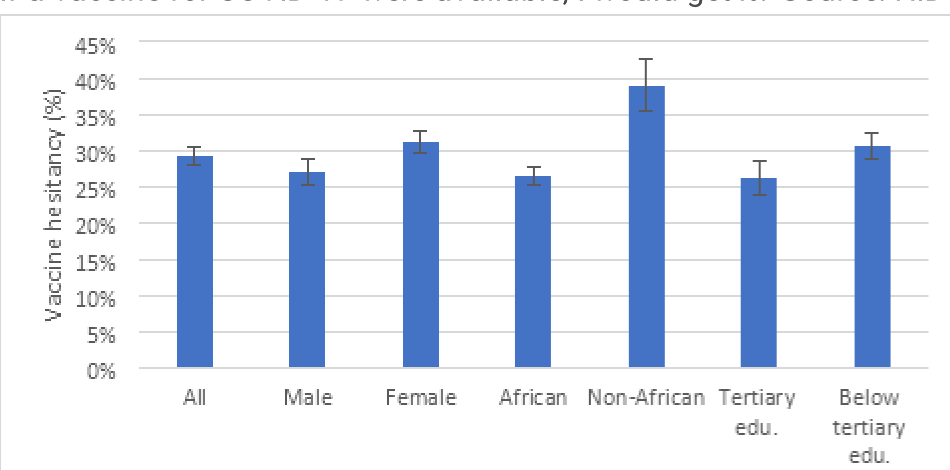

Figure 2

Vaccine hesitancy, Sex, Race and Education Source: NIDS-CRAM wave 4, weighted.

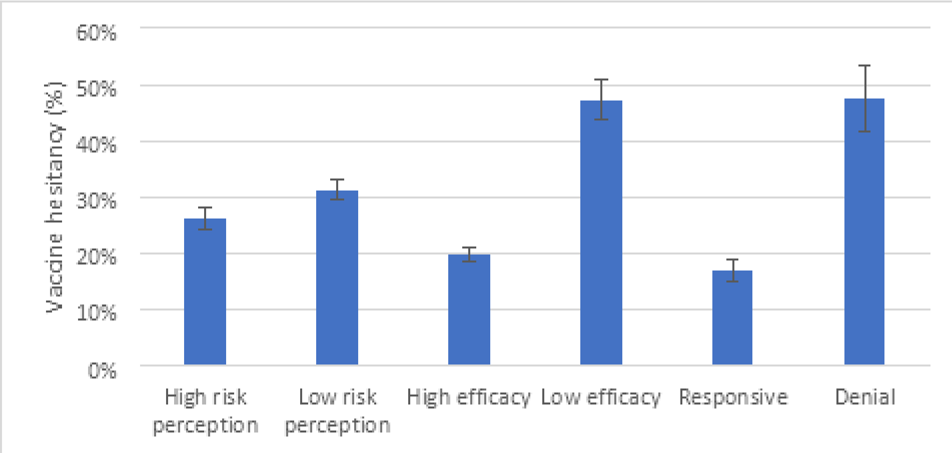

Figure 3

Vaccine hesitancy, Risk and Efficacy Source: NIDS-CRAM wave 4, weighted.

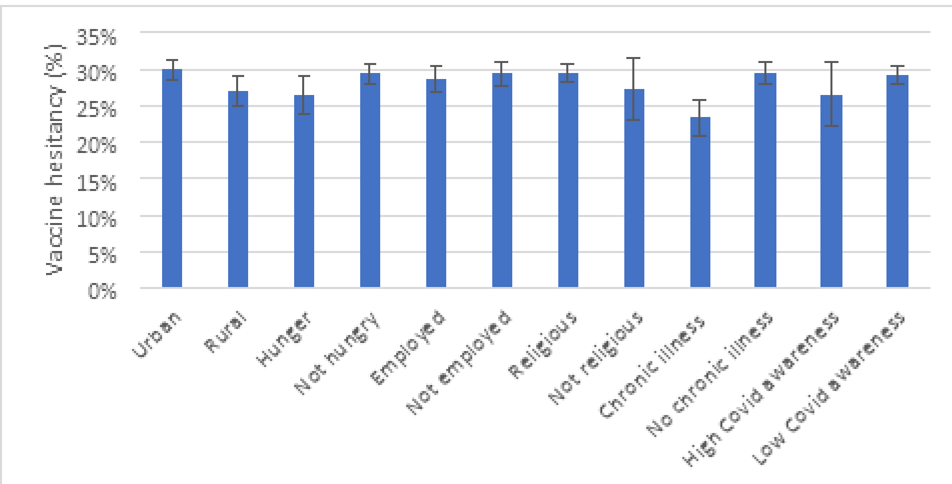

Figure 4

Vaccine hesitancy and key characteristics Source: NIDS-CRAM wave 4, weighted.

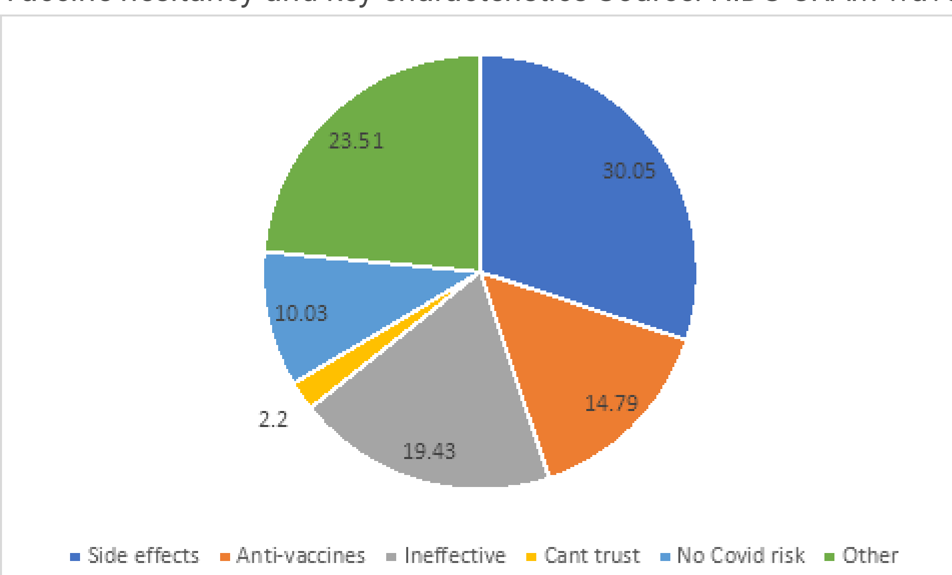

Figure 5

Reasons for Vaccine hesitancy (%) Source: NIDS-CRAM wave 4, weighted.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

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