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WAVE 5

National Income Dynamics Study (NIDS) – Coronavirus Rapid Mobile Survey (CRAM)

Mental Health, COVID-19 Vaccine Distrust and Vaccine Hesitancy in South Africa

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Abstract:

Within the context of increasing mental distress noted since the beginning of the pandemic, this study uses the 5Cs framework to analyse the role that depressive symptoms play in driving vaccine behaviour in South Africa. The study further explores pathways of this association through vaccine distrust, risk perception and efficacy. Multivariate regression analysis taking into account endogeneity concerns reveal that vaccine distrust is the most important predictor of vaccine hesitancy. There is little evidence of significant association of either pre-pandemic mental distress or current depressive symptoms with vaccine hesitancy in a fully specified model. However, significant indirect effect of depressive symptoms on vaccine hesitancy is found via vaccine distrust and risk perception.

The findings indicate that individuals at high risk of depression are more concerned regarding the safety of vaccines, which in turn feeds into vaccine hesitancy. On the other hand, depressive symptoms have an opposite effect via risk perception. Risk perception is a negative predictor of vaccine hesitancy; therefore, the enhanced risk perception leads to lower vaccine hesitancy. This study has established that the indirect effects are highly relevant and need to considered closely while analysing the relationship between mental distress and vaccine behaviour.

Lastly, the study also found significant feedback effect of mental distress with vaccine distrust as well as risk perception. Therefore, improved vaccine trust can lead to not just increased vaccine acceptance and reduced risk perception; but also, better mental health.

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Executive Summary

South Africa has experienced a surge in depressive symptoms under the COVID-19 pandemic (Oyenubi & Kollamparambil 2020). The source of this increase is attributed to the fears and anxiety of getting infected with and death from COVID-19 (Holingue et al. 2020), as well as the distress caused through large-scale economic devastation and job loss (Posel et al. 2021).

The increased mental distress can also have an impact on vaccine behaviour as acknowledged in the 5C's framework of vaccine behaviour (WHO 2014, Razai et al. 2021). While the association has been explored empirically in a few studies, none of these studies established a significant relationship between mental health and vaccine behaviour. These studies fall short as they do not consider possible indirect pathways through which mental health can impact on vaccine behaviour.

Using the National Income Dynamics Study-Coronavirus Rapid Mobile Survey (NIDS-CRAM) dataset, this study analyses the role that depressive symptoms play in driving vaccine behaviour in South Africa and further explores pathways of impact through vaccine distrust, risk perception and efficacy. The findings are as follows:

- Only 2% of the South African population had been vaccinated at the time of the NIDS-CRAM Wave 5 (April-May 2021).

- The study makes the reassuring finding that vaccine hesitancy has decreased from 29% in Feb 2021 to 24.5% in April-May 2021. During this period risk perception fell from 45% to 43%. Efficacy, on the other hand, increased from 82% to 89%. This is not surprising as South Africa was in a period of low infection rate, with lowest lockdown level 1, during the time of the fifth NIDS-CRAM wave.

- Despite this, depressive symptoms increased over the pandemic from an average PHQ-2 score of 1.3 in July-August 2020 (Wave 2) to 1.5 in April-May 2021 (Wave 5). Using the binary variable of those at risk of depression (with PHQ-2 cut-off of 3 and above), individuals at risk increased from 24.07% to 27.57% between Wave 2 and 5. Using the cut-off of 2 and above, those at risk increased from 38.73% to 42.14%.

- Vaccine hesitancy is lower amongst the Black African population group compared to non-African group.

- Consistent with Wave 2 findings (Oyenubi & Kollamparambil 2020; Posel et al. 2021), depressive symptoms during Wave 5 are found to be higher amongst the non-black group. This is starkly contrary to the observations in the pre-pandemic period, when black Africans recorded higher depressive symptoms in multiple studies (Burger et al. 2017).

- Individuals living in a household that have experienced hunger are less hesitant of the vaccine, but as expected have higher levels of depressive symptoms.

- The respondents who relied on health workers for COVID-related information had less distrust of vaccines, whereas, those dependent on social media for information had significantly higher distrust of COVID vaccine and also had higher level of vaccine hesitation.

- Almost 18% of the population reported vaccine to be unsafe or would harm them. The proportion is higher at 53% amongst individuals who are not strongly accepting of the vaccine, and 60% amongst those who are vaccine hesitant. The main reasons for vaccine distrust were concerns regarding safety and side-effects, rushed testing of the vaccine, conspiracy theories and lack of belief in the effectiveness of vaccine.

- The study finds that there is room for confidence-building measures through community leaders as role models for vaccination, and for more transparent health communication based on risk-benefit analysis of COVID-19 vaccines.

- Those with higher depressive symptoms had a statistically higher concentration of vaccine hesitancy, higher risk perception of infection, lower sense of efficacy, and higher distrust of vaccines.

- Vaccine hesitancy, vaccine distrust, and risk perception are observed to be concentrated among the upper end of the income distribution.

- Significant age-related inequality is observed, with vaccine hesitancy, vaccine distrust and self-efficacy being pro-young. On the other hand, the risk perception of infection is concentrated among higher age groups.

- There is also a significant concentration of risk perception among the more educated individuals.

- Multivariate regression analysis taking into account endogeneity concerns reveal that vaccine distrust is the most important predictor of vaccine hesitancy.

- There is little evidence of significant association of either pre-pandemic mental distress or current depressive symptoms with vaccine hesitancy in a fully specified model. However, it is clear that mental distress is closely correlated with vaccine distress and risk perception. No significant association was picked up between mental distress and efficacy.

- The indirect effect of depressive symptoms on vaccine hesitancy is found via vaccine distrust and risk perception. The findings indicate that individuals at high risk of depression are more concerned regarding the safety of vaccines, which in turn feeds into vaccine hesitancy.

- On the other hand, depressive symptoms have an opposite effect via risk perception. Risk perception is a negative predictor of vaccine hesitancy; therefore, the enhanced risk perception leads to lower vaccine hesitancy.

- Therefore, the impact of depressive symptoms on vaccine hesitancy through the mediating factors of vaccine distrust and risk perception exert contradicting influence through the two pathways. It is therefore not surprising that the net direct effect of depressive symptoms is insignificant on vaccine hesitancy. But this study has established that the indirect effects are highly relevant and need to considered closely while analysing the relationship between mental distress and vaccine behaviour.

- Lastly, the study has found feedback effect of mental distress with vaccine distrust as well as risk perception. Therefore, improved vaccine trust can lead to not just increased vaccine acceptance and reduced risk perception; but also, better mental health.

Policy implications:

- The encouraging finding is that vaccine hesitancy among adults has declined from 29% in February 2021 to 24.5% in May 2021. Considering that children are currently not intended for vaccination, higher vaccine acceptance among adults will be required to achieve community immunity.

- There is hence a need to further strengthen confidence building communication with regards to the safety of the COVID-19 vaccine. One way to achieve this is through identifying vaccine role models who carry the trust of the community and the country.

- Social media is found to enhance vaccine hesitancy and vaccine distrust. Therefore, it is

important to counter rumours and fear-mongering via this medium through more credible and fact-based information. Effective communication of risk-benefit analysis of vaccines through explainer videos is recommended to quell exacerbated fears.

- It is vital for the government and policy makers to use social media as a means of information dissemination especially to the younger adult population who are found to have the highest levels of vaccine hesitancy as well as vaccine distrust. Special attention needs to be given to address concerns of vaccine safety, vaccine testing and vaccine effectiveness especially among richer, educated and younger individuals.

- Improved mental health is expected to lower vaccine distrust, leading to a higher vaccine uptake. Improved vaccine confidence can also assist in relieving mental distress arising from elevated risk perception. Therefore, focussing on vaccine communication with better transparency relating to vaccine safety, vaccine testing, vaccine effectiveness will lead to not just better vaccine acceptance but also improve the mental wellbeing of the population.

1. Introduction

A systematic review and meta-analysis of the psychological and mental health impact of COVID-19 has shown increased prevalence of anxiety and depression among the general population (Luo et al. 2020). South Africa is no exception and it is widely acknowledged that the pandemic has resulted in a surge in depressive symptoms in the country (Oyenubi & Kollamparambil 2020). The source of this increase is attributed to the fears and anxiety of getting infected with and death from COVID-19 (Holingue et al. 2020), as well as the distress caused through large scale economic devastation and job loss (Posel et al. 2021).

While there is now acceptance of the mental health impact of the pandemic, the role that depressive symptoms play in driving vaccine behaviour and attitudes is less understood. Understanding this relationship is important to address the mental wellbeing of the population as well as to improve vaccine acceptance, in order to bring the pandemic under control.

According to the World Health Organisation Vaccine Hesitancy Working Group (WHO 2014), vaccine hesitancy is a complex behavioral phenomenon 'influenced by factors such as complacency, convenience and confidence' (3C's model of vaccine hesitancy). Complacency is driven by low infection risk perception as well as low perceived severity of infection. Confidence is driven by the self-efficacy of being able to avoid infection through non-pharmaceutical interventions or vaccines. Therefore, the perceived distrust of vaccines can lower this confidence. Lastly, convenience is related to the access and cost of vaccination.

The importance of communication and context is now increasingly acknowledged extending the 3 C's framework to 5 C's (Razai et al. 2021). The level of information as well as source of information plays a role in driving vaccine intention. Lastly, the contextual influences, which may be external as well as personal/individual experience also play a role in driving the decision regarding COVID-19 vaccines. While the external reality is constructed from social interactions, culture, religion etc.; individual factors like physical and mental health status also play a role.

Apart from the direct influence of context on vaccine intention, it is also likely to have an indirect effect on vaccine intention via the role it plays in the subjective risk-benefit assessment of vaccine confidence and complacency. The mental health of an individual therefore is expected to play a big role in this process through both direct and indirect means.

Existing studies have explored the role of personal health status in driving vaccine intention primarily through physical health status. Kollamparambil et al. (2021) found in the context of South Africa that those with chronic physical health problems are more willing to accept COVID-19 vaccines. The study however did not incorporate the relationship between vaccine behaviour and mental health conditions. Internationally as well, studies on the relationship between mental health and vaccine intention are scarce. Only a handful of studies like Batty et al. (2021), Bendau et al. (2021) and Paul et al. (2021) have examined the issue within the context of the COVID-19 pandemic.

A challenge in studying the relationship between depressive symptoms and vaccine intention is the simultaneity that exists in the direction of causation. While negative attitudes to the vaccine can lead to enhanced depression, a depressed state of mind can also impact on the vaccine perception. Batty et al. (2021) accounts for this by assessing the relationship between pre-pandemic mental health and vaccine hesitancy in the context of the UK. The study found that having a pre-pandemic mental health condition was unrelated to the willingness to take up a vaccine; whereas physical health was found to be strongly associated with vaccine uptake. However, the study does not consider the indirect channels of impact, whereby mental health impacts vaccine intention via vaccine attitude.

Similar to Batty et al. (2021), Bendau et al. (2021) found in the context of Germany that the broader constructs of unspecific anxiety and depressive symptoms were not significantly associated with vaccine acceptance. On the other hand, the study found that COVID-19-related anxiety, and fears of infection and health-related consequences correlated significantly positively with vaccine acceptance. In contrast, social and economic fears showed significant negative associations with

vaccination willingness. The authors conclude that these findings highlight the need to differentiate between several types of fears and anxiety to predict their influence on vaccine acceptance.

Paul et al. (2021) also did not find evidence of the impact of pre-existing mental and physical conditions on vaccine intent in the UK. The study is also one of the few that have examined associations between general vaccine attitudes and intent to vaccinate against COVID-19. The study found confidence in vaccine safety to be the largest determinant and concludes that negative attitudes towards vaccines are a major public health concern in the UK. Therefore, the study concludes that public health messaging should be tailored to address these concerns and specifically to women, ethnic minorities, and people with lower levels of education and incomes.

Similar conclusions are arrived at by (Thunstrom et al. 2020) in the context of the US. Thunstrom et al. does not include the mental health variable in their analysis but the study finds general mistrust in vaccines and concerns about future side effects in particular to be barriers to achieving population immunity to COVID-19 through vaccination.

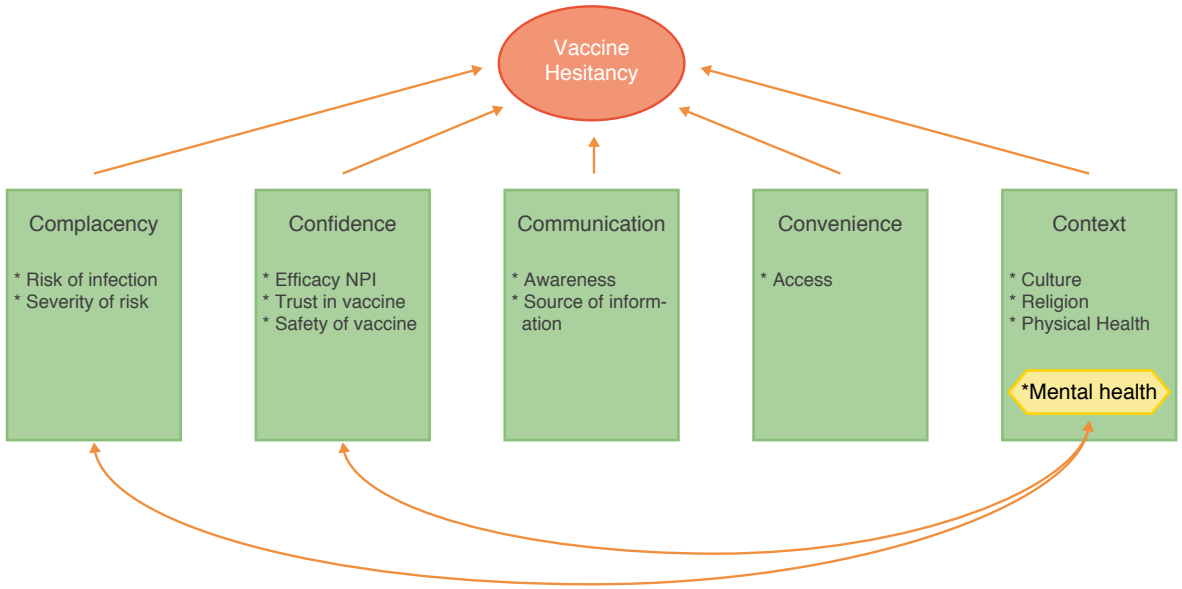
The existing literature looks at the direct effect of mental health on vaccine intention, but do not assess the indirect impact mental health may have on vaccine intention via the mediating role of vaccine attitude and other pathways such as risk perception and efficacy. Further, the limited number of existing studies exploring the role of mental health have been conducted in high-income countries. This study therefore adds value on two fronts; a) it provides a developing country perspective with high level of poverty and inequality and, b) it goes beyond the direct relationship between mental health and vaccine intent, by exploring the indirect channel of vaccine attitude through which mental health can drive vaccine behaviour.

2. Conceptual Framework

This study is framed within the framework of the 5 C's (*Figure 1*). However, it adds value to existing studies which have broadly failed to find a significant role of mental health in driving vaccine intention, by looking at the indirect effect of mental health on vaccine intention. It does so by assessing the impact that mental health exerts on vaccine intention via the mediating effect of confidence and complacency. For the purpose of this study, confidence is proxied through vaccine distrust and general reported efficacy, while complacency is proxied through the reported risk of infection.

The challenge in undertaking this analysis is the understanding that mental health would also be in turn impacted by vaccine confidence and complacency. The study therefore uses two-stage least squares as well as the internal heteroscedasticity based instrumental method (Lewbel 2012, 2018) to address the issue of simultaneity.

Figure 1: Vaccine hesitancy and mental health within the 5Cs framework



3. Data

This study is primarily based on Wave 5 of the nationally representative National Income Dynamics Study - Coronavirus Rapid Mobile Survey (NIDS-CRAM) survey. The survey investigates the socioeconomic impacts of the national lockdown associated with the State of Disaster declared in South Africa in March 2020, and the social and economic consequences of the global Coronavirus pandemic (Ingle et al. 2021).

NIDS-CRAM is a special follow up with a subsample of adults from households in the National Income Dynamics Study (NIDS) Wave 5 (2017). In addition to NIDS-CRAM, we also use the data for pre-pandemic mental health from NIDS wave 5 survey. We also supplement this, in a limited way, with data from NIDS-CRAM waves 1 and 2 when required by the analysis.

Though the NIDS-CRAM sample is drawn from the NIDS respondents, the former has a smaller sub-sample of adults compared to NIDS. The NIDS-CRAM questionnaire is also much shorter compared to NIDS questionnaire. The focus of the NIDS-CRAM questionnaire is on the Coronavirus pandemic and the national lockdown. The mode of the NIDS-CRAM survey is Computer Assisted Telephone Interviewing (CATI) surveys, repeated over several months in the preferred official South African language of the respondent. Wave 5 of the NIDS-CRAM survey had 5,862 individuals successfully interviewed over the period 6 April-11 May 2021. Wave 1 and 2, which are also used to a limited extend were undertaken during the period 7 May-27 June 2020 and; 13 July- 13 August 2020 respectively.

The study derives data on mental distress from the 2-question version of the Patient Health Questionnaire (PHQ-2)[4], viz., "*Over the last 2 weeks, have you had little interest or pleasure in doing things?*" and "*Over the last 2 weeks, have you been feeling down, depressed or hopeless*". The response to both questions could be "*not at all*", "*several days*", "*more than half the days*" or "*nearly every day*". The responses are coded from 0 to 3, resulting in a depressive score ranging from 0 to 6. The increasing values of the PHQ-2 variable indicates a higher risk of depression. The best cut-off for determining depression remains contested. While some studies (Giuliani et al 2020, Ghazisaeedi et al 2021) identify the PHQ-2 threshold of ≥ 2 as providing the ideal balance between sensitivity and specificity, others suggest a cut-off of ≥ 3 as optimal (Kroenke et al 2003). We use both thresholds in the analysis. We also use the depressive score variable as a continuum of distress to navigate the uncertainty relating to threshold determination (Ardington and Case, 2010; Burger et al., 2017; Posel et al 2021), which have been found to vary across different language groups in South Africa (Baron et al., 2017).

Pre-pandemic mental health is captured using the ten items on the Centre for Epidemiological Studies Depression (CESD-10) scale from NIDS wave 5. Each question could be responded to as "*not at all*", "*several days*", "*more than half the days*" or "*nearly every day*". The responses are coded from 0 to 3, creating the outcome variable of CESD-10 scale with a range of 0 to 30, with increasing values indicating higher risk of depression.

Vaccine intention is derived from wave 5 of NIDS-CRAM question, "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". For the purposes of binary variable creation for vaccine hesitancy, responses of 'somewhat disagree and strongly disagree" are considered to vaccine hesitant; while responses of "strongly agree, somewhat agree" are considered as vaccine willing.

Vaccine attitude is derived from two questions, "Do you believe that the vaccine is unsafe or could harm you?" (with response options of : yes/no) and "How convinced are you of this?" (with response options of: a little/somewhat/very convince). Using these questions we create an ordinal variable ranging 0-3, where 0 indicates belief in the safety of vaccine and 3 being very convinced of lack of safety.

4 PHQ-2 is the abbreviated version of the widely used PHQ-9 (Kroenke et al., 2003). It has been validated as a reliable screening method for depressive symptoms in South Africa (Baron et al., 2017)

The reasons for distrust in vaccine safety are derived from the question "*Why do you believe that the vaccine is unsafe or harmful?*". The key risk perception (complacency) 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?*'. In order to imbibe the severity of risk we additionally use two proxy variables viz., older age groups as well as those with pre-existing chronic illnesses (Kollamparambil et al. 2021). Therefore, the first proxy for severity (mortality threat) incorporated in the model is age (measured in years) and the second proxy is obtained from wave 1 of NIDS-CRAM survey which included 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?*". This question was not repeated in subsequent NIDS-CRAM waves.

The self-efficacy (confidence) variable is sourced from the 'yes' or 'no' response to the question "*Can you avoid getting Coronavirus?*". The survey instrument does not afford an opportunity to differentiate between non-pharmaceutical and vaccine related self-efficacy separately through this question. 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 non-pharmaceutical interventions (NPI) rather than vaccines.

Communication is proxied with the respondents' awareness of COVID-19 symptoms. 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 COVID-19 symptoms would also be well-informed of the vaccine (Kollamparambil et al. 2021). The source of information is also included with binary variables capturing information sources as social media, news, government and health worker. Both the awareness of COVID-19 symptoms and source of information were collected only 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.

Lastly, the convenience factor is incorporated into the model using household income based on the argument that income enables easier access and transport to vaccine centres. 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 Wittenberg (2017) 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 5,468 out of 5,862 observations.

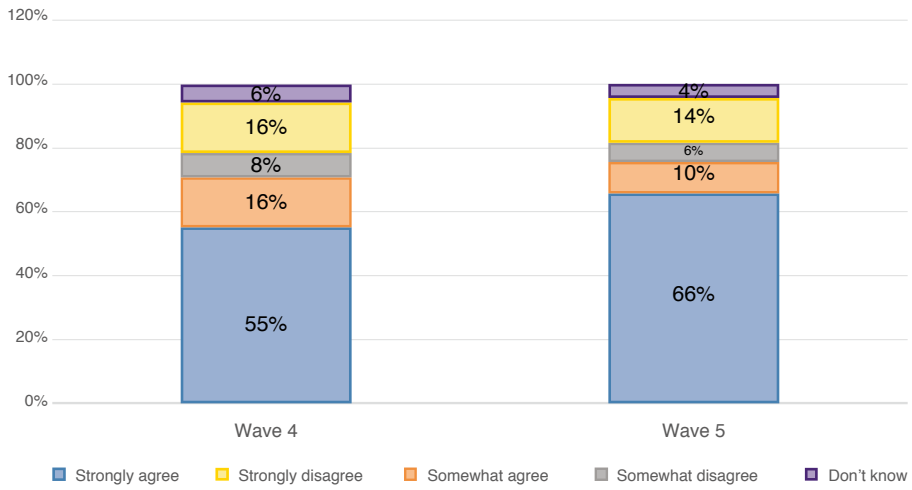
Because individual responses emerge from the context of different social, cultural, political and personal factors in vaccine decision (Callaghan et al. 2020), additional socio-economic variables such as sex(male), race (black African), partnered, location (urban) and religiosity are incorporated to get a clearer picture of the range of possible predictors about vaccine intention. It is within this category that mental health becomes an important factor. Mental health of an individual is expected to affect vaccine intention directly but also indirectly by driving confidence and complacency.

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 (Althubaiti 2016) especially for key questions like vaccine intention and vaccine distrust.

4. Preliminary analysis

At the time of the survey, only 2% of the population had been vaccinated. Vaccine hesitancy is calculated as the proportion of respondents who strongly disagreed, somewhat disagreed or didn't know about accepting vaccine. Our results show that vaccine hesitancy has declined from 29.2% in wave 4 to 24.5% in wave 5 (*Figure 2*). Also, there is a substantial shift from those who "somewhat agreed" to "strongly agreed" to the vaccine. This is a good sign; however, hesitancy still remains too high to achieve community immunity especially considering that children are not likely to be included in the vaccination target group.

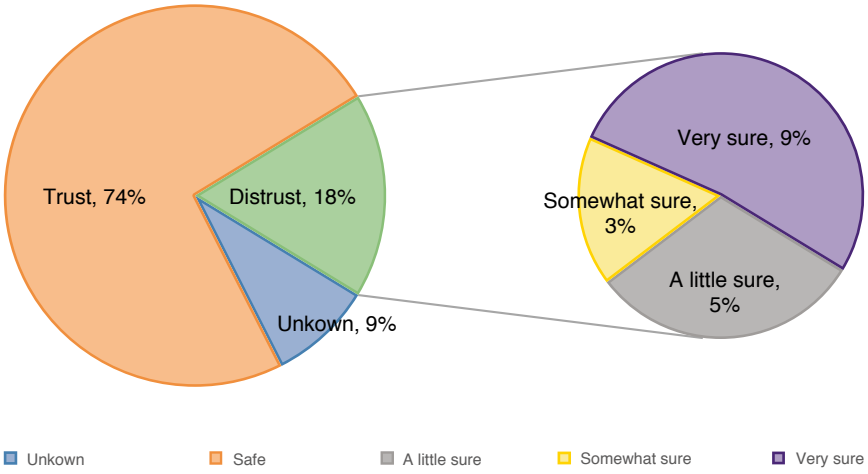
Figure 2: Vaccine intention (%)



Source: NIDS-CRAM waves 2 and 5, weighted

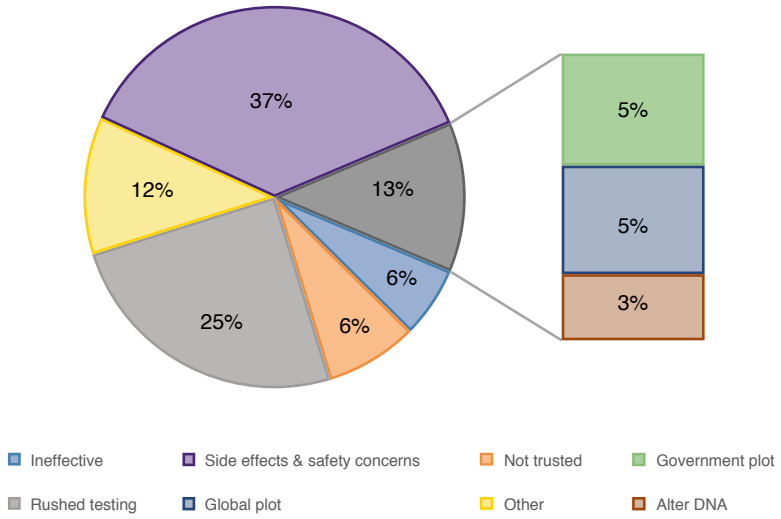
Almost 18% of the population reported COVID-19 vaccines to be unsafe or would harm them (distrust). Varying levels of certainty are reported amongst those who distrust the vaccine, with 50% of those who distrust being very sure about it (*Figure 3*). The distrust is higher at 53% amongst individuals who are not strongly accepting of the vaccine, and 60% amongst those who are vaccine hesitant.

Figure 3: Vaccine Trust perception (%)



Source: NIDS-CRAM waves 2 and 5, weighted

Figure 4: Reasons for Vaccine Distrust

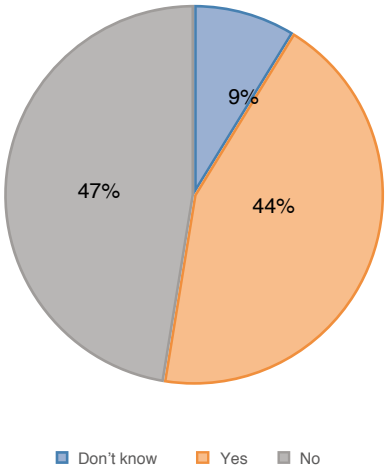


Source: NIDS-CRAM waves 2 and 5, weighted

The major reason for vaccine distrust cited by 37% related to side-effects and safety concerns (*Figure 4*). The concerns on possible side-effects included blood clot, causing cancer/HIV etc. A further 25% expressed doubts about the vaccines considering that they were not tested for sufficiently long period of time. The fast-tacked process of the development of COVID-19 vaccines appears to be a second biggest concern, following concerns regarding the side effects of the vaccine. Another 13% perceived it to be part of global/government conspiracy.

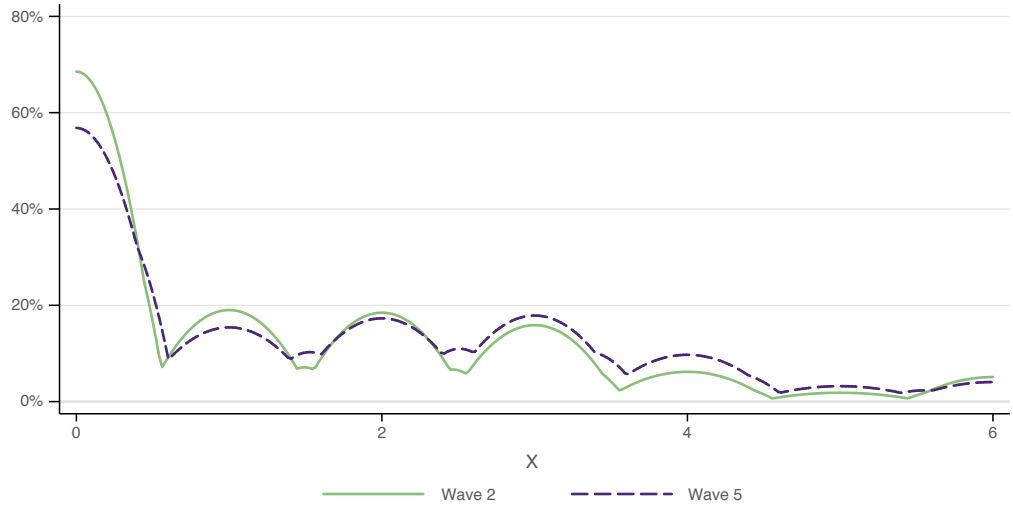
The indication that public confidence building measures could be successful in reducing vaccine hesitancy is indicated by 54% of adult population expressing willingness to be vaccinated if a trusted community leader was vaccinated and remained healthy (*Figure 5*). Although a significant 38% responded in the negative, it is an indication that further confidence building measures through better information sharing of the vaccine side-effects, testing processes, efficacy etc. are required to instil confidence with regards to COVID-19 vaccines.

Figure 5: Willing to be vaccinated if a trusted community leader was vaccinated, and remained health?



Source: NIDS-CRAM waves 2 and 5, weighted

Figure 6: Kernel density plot: PHQ-2 waves 2 and 5



Source: NIDS-CRAM waves 2 and 5, weighted

The kernel density plots of depressive scores in waves 2 and 5 indicate elevated levels of depressive symptoms with the progression of the pandemic (*Figure 6*). The average PHQ2 scores increased from 1.294 in July-August 2020 (Wave 2) to 1.487 in April-May 2021 (Wave 5). Using the binary variable of those at risk of depression (with PHQ-2 cut-off of 3), individuals at risk increased from 24.07% to 27.57% between Wave 2 and 5. Using the cut-off of 2, those at risk increased from 38.73% to 42.14%. The increased mental distress observed is despite the fact that the country was in far more relaxed lockdown level in Wave 5 (lockdown level 1) compared to Wave 2 (lockdown level 3). According to Oyenubi and Kollamparambil (2021), the increased depressive symptoms, despite lockdown level being relaxed, indicates that the economic recovery would be critical in reviving the mental health of the population.

Table 1A: Vaccine intention, distrust and risk perception: Across socio-economic categories

Variable	Obs	Vaccine Hesitant			Vaccine Distrust			Risk Perception		
		Mean	SE		Mean	SE		Mean	SE	
All	5,855	0.260	0.006		0.179	0.005		0.4297	.007	
Male	2,246	0.258	0.009		0.188	0.008		0.4416	.011	
Female	3,609	0.263	0.007		0.170	0.006		0.4188	.009	
Black African	5,065	0.237	0.006		0.172	0.005		0.4074	.008	
Non-Blacks	790	0.349	0.017	***	0.207	0.014		0.5140	.019	***
Tertiary	1,484	0.273	0.012		0.197	0.010		0.5127	.013	
Below Tertiary	4,371	0.254	0.007		0.170	0.006		0.3885	.008	***
Risk Perception	2,250	0.250	0.009		0.174	0.008				
No risk perception	3,125	0.265	0.008		0.187	0.007				
Self-Efficacy	5,140	0.251	0.006		0.180	0.005		0.4201	.007	
No Self-Efficacy	548	0.302	0.020		0.182	0.016		0.5032	.022	
Hunger	1,117	0.211	0.012		0.157	0.011		0.3763	.015	
No hunger	4,733	0.269	0.006	***	0.183	0.006		0.4401	.007	**
Employed	2,746	0.275	0.009		0.192	0.008		0.5091	.009	
Not employed	3,061	0.243	0.008		0.165	0.007		0.3432	.009	***
Religious	5,415	0.260	0.006		0.177	0.005		0.4255	.007	
Not religious	412	0.263	0.022		0.196	0.020		0.4734	.0256	
Well-informed	503	0.278	0.020		0.209	0.018		0.4976	.0232	
Not Well-informed	5,352	0.258	0.006		0.176	0.005		0.4224	.007	**
Social-media info	489	0.375	0.022		0.267	0.020		0.4868	.0232	
Not social-media	4,484	0.244	0.006	***	0.163	0.006	***	0.4214	.008	*
Govt info	592	0.271	0.018		0.182	0.016		0.4824	.0210	
Not govt info	4,381	0.259	0.007		0.175	0.006		0.4211	.007	
Health worker info	641	0.272	0.018		0.138	0.014		0.4121	.0201	
Not health worker	4,332	0.260	0.007		0.181	0.006	**	0.4319	.008	
News info	3,921	0.253	0.007		0.181	0.006		0.4332	.008	
Not news	1,052	0.294	0.014		0.158	0.011		0.4164	.016	

Source: NIDS-CRAM wave 5 and wave 1, weighted. SE is standard errors, *** p<0.01, ** p<0.05, * p<0.1

Table 1B: Mental health: Across socio-economic categories

Variable	Obs	Risk of Depression (Cut off ≥ 3)			Risk of Depression (Cut off ≥2)			Depressive scores		
		Mean	SE		Mean	SE		Mean	SE	
All	5,855	0.2757	.006		0.4214	0.006		1.464	0.022	
Male	2,246	0.2667	.009		0.4047	0.010		1.413	0.035	
Female	3,609	0.2838	.007		0.4365	0.008		1.510	0.028	
Black African	5,065	0.2558	0.005		0.4019	0.005		1.400	0.024	
Non-Blacks	790	0.3518	0.014	***	0.4958	0.014	***	1.707	0.055	***
Tertiary	1,484	0.2675	0.010		0.4013	0.010		1.402	0.042	
Below Tertiary	4,371	0.2796	0.006		0.4309	0.007		1.493	0.025	
Risk perception	2,250	0.3380	0.008		0.4997	0.010		1.710	0.035	
No risk	3,125	0.2384	0.007	***	0.3696	0.008	***	1.312	0.030	***
Self-Efficacy	5,140	0.268	0.005		0.4144	0.005		1.428	0.023	
No Self-Efficacy	548	0.326	0.016	*	0.4638	0.016		1.732	0.077	**
Hunger	1,117	0.3651	0.011		0.5894	0.011		2.081	0.056	
No hunger	4,733	0.2585	0.006	***	0.3892	0.006	***	1.345	0.023	***
Employed	2,746	0.2651	0.008		0.4089	0.008		1.424	0.031	
Not employed	3,061	0.2889	0.007		0.4369	0.007		1.512	0.030	
Religious	5,415	0.2781	0.005		0.4228	0.005		1.479	0.023	
Not religious	412	0.2534	0.020		0.4116	0.020		1.324	0.078	
Well-informed	503	0.2834	0.018		0.4404	0.018		1.480	0.073	
Not Well-informed	5,352	0.2748	0.005		0.4193	0.005		1.462	0.023	
Social-media info	489	0.2984	0.020		0.4512	0.020		1.608	0.075	
Not social-media	4,484	0.2703	0.006		0.4092	0.006		1.422	0.025	
Govt info	592	0.2617	0.016		0.4026	0.020		1.444	0.068	
Not govt info	4,381	0.2759	0.006		0.4166	0.007		1.446	0.025	
Health worker info	641	0.2676	0.014		0.4211	0.095		1.480	0.065	
Not health worker	4,332	0.2746	0.006		0.4139	0.007		1.442	0.025	
News info	3,921	0.2796	0.006		0.4243	0.007		1.465	0.026	
Not news	1,052	0.2501	0.011		0.3743	0.015		1.368	0.051	

Source: NIDS-CRAM wave 5 and wave 1, weighted. SE is standard errors, *** p<0.01, ** p<0.05, * p<0.1

An assessment of vaccine intention, vaccine distrust and perceived risk of infection across socio-economic categories points to some interesting differences. The Black African population group has a lower level of vaccine hesitancy compared to the non-African group. There is also significant difference in those at risk of depression between the population groups, with the non-African group recording higher symptoms using all three measures of mental distress. This is starkly contrary to the observations in the pre-pandemic period, when the African group recorded higher depressive symptoms in multiple studies (Burger et al. 2017). The shift during the pandemic is explained by Posel et al. (2021) as due to the "steeling effect" amongst the black African group that has enabled them to better face the adversity of the pandemic compared to the more privileged groups. Oyenubi & Kollamparambil (2020) moots an additional explanation citing the conservation of resource theory (Hobfoll et al., 2016), whereby those who have more to lose tend to experience a greater sense of loss leading to higher depressive symptoms.

Risk perception is positively associated with both measures of risk of depression as well as depressive scores. Individuals living in households that have experienced hunger are less hesitant of the vaccine, explained possibly by their willingness to take additional risk given their dire economic situation. As expected, individuals from households that have experienced hunger have higher levels of depressive symptoms. The respondents who relied on health workers for COVID related information had less distrust of vaccines whereas, those dependent on social media for information had significantly higher distrust of covid vaccines and also had higher level of vaccine hesitation. The indications therefore point to the need to counter rumours and misinformation spread through social media with more reliable and credible information from health workers.

5. Socioeconomic and Mental distress inequality in vaccine attitudes and intention

In this section, we make use of Erreygers-corrected concentration indices to assess the socio-economic and mental distress related inequality in vaccine attitudes and intention. The socio-economic distributions considered are household per capita income, age, and schooling. The mental distress variable is ordinal in nature ranging from 0-6; therefore the starting point of the analysis following van Doorslaer and Jones (2003) is the derivation of a 'latent index' variable for mental distress by regressing quasi-objective measures of mental distress on self-reported mental distress status and then predicting people's self-reported mental distress status using an ordered logit regression (Appendix *Table A1*).

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

	Depressive Symptoms		Pre-existing CESD10		Income		Age		Education	
	CI	SE	CI	SE	CI	SE	CI	SE	CI	SE
Vaccine hesitancy	0.063**	-0.03	0.012	0.020	.052**	-0.02	-.0882***	-0.02	0.008	-0.01
Vaccine distrust	.051**	-0.03	0.001	0.018	.035**	-0.02	-.074***	-0.01	.034**	-0.01
Efficacy	-.133***	-0.02	0.008	0.016	-0.008	-0.01	-.012**	0.00	0.005	-0.01
Risk	.593***	-0.02	-0.031	0.025	.184***	-0.03	.092***	-0.02	.099***	-0.02
Community leader	.068***	-0.02	-0.034*	0.019	-0.003	-0.02	-.117***	-0.02	0.005	-0.02

Source: NIDS-CRAM wave 5, weighted. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

The concentration indices reveal that those with higher depressive symptoms have a statistically higher concentration of vaccine hesitancy, higher risk perception of infection, lower sense of self-efficacy or confidence in avoiding infection, and higher distrust of vaccines. These results can be taken as preliminary indication of the association between depressive symptoms with vaccine attitudes and intentions.

The results of Kollamparambil et al. (2021) are validated here with regard to income-related inequality. A higher concentration of vaccine hesitant individuals is observed among the upper end of the income distribution. Not surprising therefore there is a similar concentration of vaccine unsafe perception in the upper tail of the income distribution. Although not statistically significant, the negative concentration index of self-efficacy along the income distribution indicates that the poor are more confident about avoiding infection. Risk perception on the other hand is observed to be pro-rich.

Significant age-related inequality is observed, with vaccine hesitancy, vaccine unsafe perception and the belief that infection can be avoided being pro-young. On the other hand, the risk perception of infection is concentrated among higher age groups.

The education-related inequality is also significant for vaccine distrust but not for vaccine hesitancy. There is also a significant concentration of risk perception among the more educated individuals.

6. Multivariate Regression analysis

The preceding analysis has been bivariate, and although they give an indication of the association between mental distress and key variables such as vaccine intention and attitudes, they do not control for other confounding factors. The multivariate regression controls for a range of variables that drive vaccine behaviour and attitude. The sample for the multivariate analysis is given in *Table 3*.

The sample is broadly reflective of the national population with the black African population accounting for over 78% of the population and the sex ratio in favour of females. The depressive score from Wave 5 (April/May 2021) is higher than in Wave 2 (July/August 2020) indicating increased mental distress over the pandemic period, despite the opening up of the economy. Vaccine distrust and hesitancy are reported at 39% and 25% respectively.

A higher proportion of respondents (89%) held the view that infection could be avoided in wave 5 compared to 82% in wave 4 (Kollamparambil et al. 2021). The risk perception seems to have lowered with 43% indicating likelihood of infection in Wave 5, compared to 45% in Wave 4.

Table 3: Descriptive statistics of regression sample

Variable	Obs	Mean	Std. Dev.	Min	Max
Risk of depression(cut-off ≥3)	4,098	.2901	.4538	0	1
Risk of depression(cut-off ≥2)	4,098	.4242	.4942	0	1
Depressive score	4,098	1.487	1.685	0	6
PHQ2@	3,530	1.294	1.632	0	6
CESD-10 ^	4,098	6.474	4.258	0	26
Vaccine distrust	4,098	0.388	0.916	0	3
Vaccine Hesitancy	4,098	0.251	0.433	0	1
Can avoid infection	4,098	0.892	0.310	0	1
Will get infected	4,098	0.433	0.496	0	1
Age, years	4,098	40.842	14.692	18	98
Chronic	4,098	0.190	0.392	0	1
Household income pc	4,098	3066	6268	0	65000
Schooling, years	4,098	11.497	3.729	0	22
African	4,098	0.786	0.410	0	1
Male	4,098	0.472	0.499	0	1
Married	4,098	0.476	0.499	0	1
Employed	4,098	0.537	0.499	0	1
Religious	4,098	0.919	0.273	0	1
Experienced hunger	4,098	0.158	0.365	0	1
Social media info#	4,098	0.134	0.340	0	1
Government info#	4,098	0.143	0.350	0	1
Health worker info#	4,098	0.097	0.297	0	1
News info#	4,098	0.805	0.396	0	1
COVID awareness #	4,098	0.115	0.320	0	1

Source: NIDS-CRAM Wave 5, # NIDS-CRAM Wave 1, @ NIDS-CRAM Wave 2, ^ NIDS Wave 5, weighted.

In order to identify the drivers of vaccine hesitancy, we first undertake a baseline estimation of a logit model controlling for the five Cs identified in the literature. The baseline multivariate logit regression function to be estimated will be:

$$Vac\_H_i = \beta_0 + \beta_1(Vac\_D_i) + \beta_2\left(Pre\_Dep_i\right) + \beta_3\left(Covid\_Dep_i\right) + \gamma X_i + \varepsilon_i \quad (1)$$

where:

Vac_H_i denotes vaccine hesitancy taking the value 1 for person i who is unwilling to accept vaccination, and 0 for others

Vac_D_i denotes vaccine distrust, taking value 0 to 3 , with 3 denoting lowest level of trust,

Pre_Dep_i is the pre-pandemic level of CESD-10 depressive symptoms score taking value 0 to 30, with 30 denoting highest risk of depression,

$Covid\_Dep_i$ is the PHQ2 depressive symptoms observed currently during the pandemic ranging 0-6

Xi denotes a vector of explanatory variables that include confidence, complacency, communication, convenience and context that characterize individual i and,

ε_i encapsulates the error term.

Table 4: Logit regression results

	(1)	(2)	(3)
VARIABLES	**Vaccine Hesitancy**	**Vaccine Hesitancy**	**Vaccine Hesitancy**
Vaccine Distrust	1.467***	1.481***	
	(0.115)	(0.109)	
Pre-pandemic dep	0.0284*		0.0244*
	(0.0168)		(0.0144)
Covid_dep	0.0347	0.0304	0.0740**
	(0.0452)	(0.0445)	(0.0356)
Risk perception	-0.0788	-0.138	-0.123
	(0.160)	(0.159)	(0.124)
Efficacy	-0.337	-0.268	-0.316*
	(0.218)	(0.217)	(0.180)
Age yrs	-0.0215***	-0.0477*	-0.0270***
	(0.00832)	(0.0264)	(0.00663)
Above 60 years	0.731**	0.730**	0.773***
	(0.317)	(0.315)	(0.274)
Chronic illness	-0.196	-0.303	-0.0569
	(0.199)	(0.200)	(0.152)
Household income pc.	-0.0144	0.0465	0.0223
	(0.0605)	(0.0622)	(0.0502)
School yrs	-0.0447**	-0.0550***	-0.0390**
	(0.0210)	(0.0213)	(0.0180)
African	-0.658***	-0.539**	-0.580***
	(0.235)	(0.226)	(0.187)
Male	-0.110	-0.158	-0.148
	(0.165)	(0.164)	(0.134)
Married	0.0615	0.0722	-0.0340
	(0.159)	(0.164)	(0.132)
Employed	0.171	0.217	0.170
	(0.179)	(0.168)	(0.137)
Religious	0.0829	0.108	-0.0918
	(0.247)	(0.247)	(0.232)
Hunger	-0.355*	-0.306*	-0.175

	(0.191)	(0.185)	(0.162)
Social media info	0.381	0.394*	0.570***
	(0.243)	(0.231)	(0.186)
Government info	0.0142	-0.102	-0.00713
	(0.225)	(0.224)	(0.188)
Health worker info	0.341*	0.286	0.113
	(0.194)	(0.191)	(0.177)
News info	-0.325*	-0.387**	-0.169
	(0.174)	(0.182)	(0.149)
Well-informed	-0.375	-0.362	-0.102
	(0.258)	(0.242)	(0.209)
Constant	0.324	0.557	0.825
	(0.716)	(0.838)	(0.583)
Wald chi2(21)	240.23***	264.61***	66.01***
Pseudo R2	0.28	0.28	0.04
Observations	4,098	4,098	4,098

Source: NIDS-CRAM, weighted. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

The results presented in *Table 4* indicate that vaccine distrust is the strongest predictor of vaccine hesitancy. Mental distress, proxied through the depressive scores are not significant in model 1. This does not change even when the pre-pandemic depressive scores are dropped from the specification. However, once vaccine distrust is dropped, current mental distress is observed to be significant in model 3 at 95% confidence level. This points to a significant association between mental distress and vaccine distrust resulting in multicollinearity in models 1 and 2. Pre-pandemic mental distress is now significant at 90% confidence level in model 3.

Other results emerging are that age and education reduce vaccine hesitancy. Black African population group and those who have experienced hunger have on average lower hesitancy. Those who depend on news for information have lower hesitancy, while those who depend on social media for information have higher hesitancy.

Although model 3 points to strong association between mental distress and vaccine hesitancy, the estimate is likely to suffer from endogeneity bias resulting from simultaneity between the two variables. To address this, we proceed to undertaking two-stage least squares and internal heteroscedasticity based instrumental method (Lewbel 2012, 2018) estimation.

The PHQ2 score from wave 2 of the NIDS-CRAM survey is used as an instrument for mental distress. Since Wave 2 was conducted over July/August 2020, before the COVID-19 vaccines were developed, it can be argued that the depressive scores are unrelated to the attitude towards the vaccine. The PHQ2 from wave 2 is expected to impact vaccine hesitancy only through its association with the mental distress observed in wave 5, thereby fulfilling the exogeneity condition. The highly significant coefficient of Wave 2 PHQ and a goodness of fit in the first stage regression underlines the validity of the instrument.

While 2SLS is considered more efficient, the cardinality assumption is violated by the endogenous mental distress variable. Hence, we present a robustness check through the Lewbel's internal

heteroscedasticity based instrumental estimation (*Table A2*). The results of two-stage least squares as well as Lewbel estimation are consistent with model 1 in *Table 4*. Since the Wu-Hausman F test (*Table A2*) does not lead to the rejection of the null of exogeneity, we interpret the results based on *Table 4*.

Further, as an additional check we run the regressions without the Wave 1 variables relating to level and respondent identified source of reliable COVID information. This increases the sample size to 4609 observations and the results remain consistent.

Our findings are in line with other studies like Paul et al. (2021), Thunstrom et al. (2020), Sherman et al. (2020), and Williams et al. (2020) that suggest that the largest behavioural and attitudinal barrier to receiving a COVID-19 vaccine is the general mistrust against the COVID-19 vaccine. While our results are able to pick up a mild association between pre-COVID mental distress and vaccine hesitancy, there is no evidence of current mental distress having a significant association with vaccine hesitancy in a fully specified model. The absence of a strong association between mental distress and vaccine hesitancy is in keeping with evidence from UK and Germany (Batty et al. 2021, Bendau et al. 2021, Paul et al. 2021).

The close correlation between current depressive symptoms and vaccine attitude is clear from the model where the former is significant when the latter is excluded from the model. Therefore, current mental distress may not have a direct effect on vaccine intention but impacts it indirectly via vaccine attitude, confidence and complacency. The indirect effects are assessed through the following regression specification:

$$Vac\_D_i / \ Risk\_P_i \ / \ Efficacy_i = \beta_0 + \beta_1\left(Covid\_Dep_i\right) + \beta_2\left(Pre\_Dep_i\right) + \ \gamma X_i + \varepsilon_i \quad (2)$$

For a simple, benchmark estimate of the effect of land-ownership on subjective wellbeing given that:

Vac_D_i denotes vaccine distrust, taking value 0 to 3 , with 3 denoting lowest level of trust,

$Risk\_P_i$ denotes risk perception, taking the value 0 for those who do not perceive risk of infection, and 1 for those who do

$Efficacy_i$ takes the value 0 for those that believe that infection cannot be prevented, and 1 for those who do.

$Covid\_Dep_i$ is the PHQ2 depressive symptoms observed currently during the pandemic ranging 0-6,

Xi denotes a vector of explanatory variables that include confidence, complacency, communication, convenience and context that characterize individual i and,

ε_i encapsulates the error term

Ordinal logit regression is estimated for vaccine distrust given the ordinal nature of the dependent variable. Both risk perception and self-efficacy are estimated as binomial logit regressions. The results (*Table 5*) suggest that current depressive symptoms are strongly correlated with vaccine distrust and risk perception. However, the association between current depressive symptoms and self-efficacy is not significant. Pre-pandemic mental distress is not significantly associated with vaccine distrust, risk perception or efficacy.

Table 5: Ordinal/binomial logit results

	(Ordinal Logit)	(Logit)	(Logit)
VARIABLES	**Vaccine distrust**	**Risk Perception**	**Self-Efficacy**
Covid dep	0.0997***	0.181***	-0.0723
	(0.0361)	(0.0336)	(0.0500)
Pre-Pandemic dep	0.0127	-0.00735	0.00124
	(0.0160)	(0.0141)	(0.0191)
Age	-0.0367	0.0764***	-0.0168
	(0.0253)	(0.0249)	(0.0307)
Age squared	0.000130	-0.000783***	0.000195
	(0.000272)	(0.000271)	(0.000317)
Chronic illness	0.138	0.000979	-0.148
	(0.185)	(0.136)	(0.190)
Household income pc.	0.0753	0.120**	-0.0242
	(0.0576)	(0.0508)	(0.0603)
Schooling yrs	-0.00192	0.0355**	0.0306
	(0.0203)	(0.0158)	(0.0268)
African	-0.318	-0.214	0.847***
	(0.208)	(0.177)	(0.212)
Male	0.0237	-0.0123	-0.142
	(0.143)	(0.117)	(0.157)
Married	-0.0965	0.207*	-0.509***
	(0.169)	(0.120)	(0.189)
Employed	0.0310	0.406***	-0.0227
	(0.159)	(0.126)	(0.186)
Religious	-0.307	-0.125	0.112
	(0.220)	(0.204)	(0.303)
Hunger	-0.0128	-0.231	0.127
	(0.177)	(0.150)	(0.215)
Constant		-3.345***	1.945**
		(0.669)	(0.850)
Wald chi2	52.7***	110.7***	42.4***
Pseudo R2	0.0216	0.0579	0.0398
Observations	4,338	4,338	4,338

Source: NIDS-CRAM, weighted. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1
Note: cut10.575 cut2: 1.031, cut3: 1.332*

The baseline logit estimations do not account for the possible simultaneity in the relationship between the dependent variables and mental distress. Therefore, to weed out possible endogeneity bias we undertake the two-stage least squares instrumental variable (2SLS) regression. The instrumental variables employed are: PHQ-2 from wave 2 (prior to the vaccines being developed) and pre-pandemic CESD-10 score. The PHQ2 score from wave 2 of the NIDS-CRAM survey is used as an instrument for current mental distress.

Table 6: Two-stage least squares results

	(1)	(2)	(3)
VARIABLES	**Vaccine distrust**	**Risk Perception**	**Self-Efficacy**
Covid dep	0.0966**	0.113***	-0.00107
	(0.0458)	(0.0257)	(0.0158)
Pre-pandemic dep	0.00703**	-0.000532	0.00114
	(0.00347)	(0.00200)	(0.00119)
Age yrs	-0.0224***	0.0139***	-0.000590
	(0.00546)	(0.00318)	(0.00189)
Age squared	0.000165***	-0.000116***	1.45e-06
	(5.72e-05)	(3.37e-05)	(2.00e-05)
Chronic illness	-0.0175	0.0139	-0.0134
	(0.0354)	(0.0206)	(0.0123)
Household income pc.	0.0173	0.0380***	-0.00338
	(0.0120)	(0.00704)	(0.00420)
Schooling yrs	-0.000425	0.00733***	0.00162
	(0.00425)	(0.00249)	(0.00147)
African	-0.0985*	-0.000935	0.0934***
	(0.0545)	(0.0313)	(0.0190)
Male	0.0114	-0.00474	-0.00440
	(0.0312)	(0.0180)	(0.0107)
Married	0.0103	0.0422**	-0.0242**
	(0.0310)	(0.0181)	(0.0107)
Employed	0.0237	0.0581***	0.00172
	(0.0327)	(0.0188)	(0.0112)
Religious	-0.0853	0.00758	0.0141
	(0.0590)	(0.0344)	(0.0207)
Hunger	0.00357	-0.0444	0.00447
	(0.0524)	(0.0301)	(0.0182)
Constant	0.818***	-0.466***	0.843***

	(0.181)	(0.103)	(0.0624)
Wald chi2(13)	105.95***	211.14***	81.49***
Observations	3,530	3,591	3,638
Sargan chi2(1)	2.918*	0.0704	2.785*
Wu-Hausman F test	3.5108*	8.0495***	.08096
Observations	4,098	4,098	4,098
R-squared	0.009	0.008	0.021

Source: NIDS-CRAM, weighted. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

The Wu-Hausman test indicates the presence of endogeneity for the risk perception regression. The null of exogeneity is not rejected for self-efficacy and vaccine distrust at 95% confidence level. Therefore, the indications are that the results presented in *Table 5* hold for vaccine distrust and self-efficacy estimations. Since simultaneity is established in the risk perception estimation, the 2SLS estimation is better suited to identify its correlates. The Sargan test is not rejected at 99% confidence level in the risk perception model.

The result of the baseline and 2SLS estimations are remarkably similar with current mental distress emerging as an important predictor for vaccine distrust and risk perception, but not for efficacy. Although the consistent results from two separate estimations are re-assuring, a standard two stage least squares (2SLS) estimation may not be appropriate in the current context due to the non-cardinal nature of the potentially endogenous current mental distress variable that raises the possibility of treatment selection bias.

Therefore, we supplement the estimations further with an identification strategy that constructs internal instrumental variables based on the presence of heteroskedasticity in the data, proposed by Lewbel (2012, 2018) using the STATA module ivreg2h developed by Baum et al. (2012). The Hansen J test is used to test the overidentifying restriction.

Table 7: Heteroscedasticity based internal instrumental variable Lewbel regression results

	(1)	(2)	(3)
VARIABLES	**Vaccine Distrust**	**Risk Perception**	**Self-Efficacy**
Covid dep	0.0785**	0.0632**	-0.000866
	(0.0376)	(0.0278)	(0.0183)
Self-Efficacy	-0.0670		
	(0.0729)		
Risk perception	-0.0867		
	(0.0551)		
Age yrs	-0.00414	0.0213***	-0.000841
	(0.00740)	(0.00486)	(0.00256)
Age squared	3.50e-06	-0.000225***	1.56e-05
	(7.33e-05)	(5.14e-05)	(2.67e-05)
Chronic illness	0.0500	-0.0168	-0.0310
	(0.0660)	(0.0325)	(0.0211)
Household income pc	0.0231	0.0445***	0.000630
	(0.0147)	(0.00988)	(0.00544)
School yrs	0.000924	0.00999***	0.00302
	(0.00592)	(0.00370)	(0.00266)
Married	-0.0959*	0.0670**	-0.0548***
	(0.0527)	(0.0284)	(0.0182)
Male	-0.00695	0.00599	0.00214
	(0.0471)	(0.0273)	(0.0159)
Religious	-0.131	-0.0119	-0.0276
	(0.0954)	(0.0491)	(0.0311)
African	-0.137*	-0.0225	0.0947***
	(0.0708)	(0.0433)	(0.0292)
Constant	0.602**	-0.529***	0.843***
	(0.273)	(0.141)	(0.0950)
Hansen J	20.5	12.7	12.6
J-Prob	0.363	0.754	0.703
Observations	4,098	4,098	4,098
R-squared	0.012	0.065	0.025

Source: NIDS-CRAM, weighted. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Instrumented: Covid dep; Included instruments: self-efficacy, risk perception, age, age squared, chronic illness, Household income pc, Schooling, African, Male, Married, Religious

Excluded instruments: w2PHQ2, Covid dep_ self-efficacy_g, Covid dep _getcovid_g, Covid dep _ageyrs_g, Covid dep _age squared_g, Covid dep _chronic_g, Covid dep _ Household income pc_g, Covid dep_Schooling_g, Covid dep _married_g, Covid dep _male_g, Covid dep _religious_g, Covid dep _African_g

The internal heteroscedasticity based instrumental estimations once again reinforce the results of the baseline and 2SLS results that current mental distress is a strong predictor of vaccine distrust and risk perception, but not of self-efficacy (*Table 7*). We are therefore able to conclude that although there is little evidence of current mental distress having a direct effect on vaccine hesitancy, it nevertheless indirectly drives vaccine behaviour through the mediating variables of vaccine distrust and risk perception.

Depressive symptoms are found to enhance vaccine distrust and risk perception. The increased vaccine distrust in turn results in increased vaccine hesitancy. On the other hand, depressive symptoms have an opposite effect via risk perception. Risk perception is a negative predictor of vaccine hesitancy; therefore, the enhanced risk perception leads to lower vaccine hesitancy. The contradicting effects of the two pathways through which mental distress impacts on vaccine hesitancy may explain why the net direct effect is insignificant in *Table 4*. But we have established that indirect effects are highly relevant and need to considered closely while analysing the relationship between mental distress and vaccine behaviour.

These results hold using the mental health variable in binary form (Appendix *Table A3*).

7. Findings

The survey results indicated that only 2% of the South African population had been vaccinated. However, the study makes the reassuring finding that vaccine hesitancy has decreased from 29% in February/March 2021 to 24.5% in April/May 2021. During this period risk perception fell and self-efficacy (to avoid infection) increased. This is not surprising as South Africa was in a period of low infection rate during the time of the fifth NIDS-CRAM wave. Despite this, the depressive symptoms have increased over the pandemic from an average PHQ-2 score of 1.294 in Wave 2 to 1.487 in Wave 5. Those at risk of depression (with PHQ-2 cut-off of 3), increased from 24.07% to 27.57% of the population.

An assessment of vaccine intention, vaccine distrust and mental distress across socio-economic categories point to some interesting differences. Vaccine hesitancy is lower amongst the Black African population group compared to the non-Black group. There is also significant difference in the depressive symptoms between the population groups with the non-Black group recording higher symptoms. This is starkly contrary to the observations in the pre-pandemic period, when the African group recorded higher depressive symptoms in multiple studies (Burger et al. 2017). Individuals living in a household that have experienced hunger have higher levels of depressive symptoms.

The respondents who relied on health workers for COVID-19 related information had less distrust of vaccines whereas, those dependent on social media for information had significantly higher distrust of COVID-19 vaccines and also had higher level of vaccine hesitation.

Almost 18% of the population reported COVID-19 vaccines to be unsafe or would harm them. The proportion is higher at 53% amongst individuals who are not strongly accepting of the vaccine, and 60% amongst those who are vaccine hesitant. The main reasons for vaccine distrust were concerns regarding safety concerns arising from possible side-effects, inadequate testing of the vaccine, conspiracy theories and lack of belief in the effectiveness of vaccine. It is clear that there is room to put in place confidence-building measures through community leaders as role models, but also

through better health communication on the risks and benefits of COVID-19 vaccines.

Vaccine hesitancy, vaccine distrust, and risk perception are found to be concentrated among those with higher depressive symptoms. On the other hand, general self-efficacy is concentrated among those with low depressive symptoms.

Multivariate regression analysis taking into account endogeneity concerns reveal that vaccine distrust is the most important predictor of vaccine hesitancy. There is little evidence of significant association of either pre-pandemic mental distress or current depressive symptoms with vaccine hesitancy in a fully specified model. However, it is clear that mental distress is closely correlated with vaccine distress and risk perception.

The indirect effect of depressive symptoms on vaccine hesitancy is found via vaccine distrust and risk perception. The findings indicate that individuals at high risk of depression are more concerned regarding the safety of vaccines, which in turn feeds into vaccine hesitancy.

On the other hand, depressive symptoms have an opposite effect via risk perception. Risk perception is a negative predictor of vaccine hesitancy; therefore, the enhanced risk perception leads to lower vaccine hesitancy.

Therefore, depressive symptoms impact on vaccine hesitancy through the mediating factor of vaccine distrust and risk perception but exert contradicting influence through the two pathways. It is therefore not surprising that the net direct effect of depressive symptoms is insignificant on vaccine hesitancy. But this study has established that the indirect effects are highly relevant and need to considered closely while analysing the relationship between mental distress and vaccine behaviour.

Lastly, the study has found feedback effect of mental distress with vaccine distrust as well as risk perception. Therefore, improved vaccine trust can lead to not just increased vaccine acceptance and reduced risk perception; but also, better mental health.

8. Policy implications

The encouraging finding is that vaccine hesitancy among adults has declined from 29% in February/March 2021 to 25% in April/May 2021. Considering that children are not intended for vaccination, higher vaccine acceptance among adults will be required to achieve community immunity.

There is hence a need to further strengthen confidence building communication with regards to the safety of the COVID-19 vaccine. One way to achieve this is through vaccine role models among individuals who carry the trust of the community and the country.

Social media is found to enhance vaccine hesitancy and vaccine distrust, and therefore it is important to counter rumours and fear-mongering via this medium through more credible and fact-based information. It is vital for the government and policy makers to use social media as a means of information dissemination especially to the younger adult population who are found to have the highest levels of vaccine hesitancy as well as vaccine distrust. Special attention needs to be given to address concerns of vaccine safety, vaccine testing and vaccine effectiveness.

Improved mental health is expected to lower vaccine distrust, leading to a higher uptake of vaccines. Increasing vaccine confidence can also assist in relieving mental distress arising from elevated risk perception. Therefore, focussing on vaccine communication with better transparency relating to vaccine safety, vaccine testing, and vaccine effectiveness will lead to not just better vaccine acceptance but also improve the mental wellbeing of the population.

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Appendix

Table A1: Ordered logit regression: Depressive symptom prediction

	(1)
VARIABLES	**w5_depression**
Pre-pandemic dep	0.0323***
	(0.0119)
w2_PHQ2	0.216***
	(0.0353)
Self-efficacy	-0.0873
	(0.173)
Risk perception	0.504***
	(0.107)
Age yrs	0.00578
	(0.0194)
Age squared	-0.000195
	(0.000207)
Chronic illness	0.341***
	(0.122)
Household income pc	-0.162***
	(0.0429)
Schooling yrs	-0.0270*
	(0.0159)
African	-1.022***
	(0.172)
Male	0.0938
	(0.106)
Married	-0.134
	(0.113)
Employed	-0.0636
	(0.110)
Religious	0.312
	(0.199)
Urban	-0.254*

	(0.131)
/cut1	-2.201***
	(0.621)
/cut2	-1.577**
	(0.622)
/cut3	-0.918
	(0.620)
/cut4	0.147
	(0.617)
/cut5	1.108*
	(0.623)
/cut6	1.722***
	(0.619)
Observations	3,388

Source: NIDS-CRAM, weighted. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table A2: Vaccine hesitancy-two stage least squares and Lewbel regression

vac_hesitancy	(1)	(2)
VARIABLES	**2SLS#**	**Lewbel@**
Covid dep	0.0319	-0.0102
	(0.0199)	(0.0137)
Vaccine distrust	0.259***	0.268***
	(0.00709)	(0.0111)
Self-efficacy	-0.0395*	-0.0423
	(0.0212)	(0.0289)
Risk perception	-0.0228	-0.0101
	(0.0158)	(0.0201)
Age yrs	-0.00633***	-0.00479
	(0.00234)	(0.00352)
Age squared	6.45e-05***	3.90e-05
	(2.48e-05)	(3.73e-05)
Household income pc.	0.00628	0.000951
	(0.00529)	(0.00662)
Schooling yrs	-0.00450**	-0.00637**
	(0.00184)	(0.00248)
Chronic illness	-0.0205	-0.0331
	(0.0152)	(0.0215)
African	-0.0740***	-0.0827**
	(0.0225)	(0.0348)
Male	-0.0422***	-0.0145
	(0.0133)	(0.0194)
Married	0.00717	0.00156
	(0.0132)	(0.0189)
Employed	0.0158	0.0260
	(0.0138)	(0.0199)
Religious	-0.0211	-0.0332
	(0.0250)	(0.0344)
Hunger	-0.0333	-0.0158
	(0.0225)	(0.0234)
socialmedia_info	0.0114	0.0716**

	(0.0211)	(0.0350)
gov_info	0.0100	0.00583
	(0.0188)	(0.0276)
health_worker_info	0.0276	0.0526
	(0.0194)	(0.0482)
news_info	-0.0162	-0.0466**
	(0.0161)	(0.0236)
Well-informed	-0.0143	-0.0428
	(0.0208)	(0.0277)
Constant	0.398***	0.487***
	(0.0819)	(0.111)
Sargan chi2(1)	0.6873	
Wu-Hausman F(1,3508)	2.67	
Hansen J		28.4
Observations	3,530	3,530
R-squared	0.308	0.330

Source: NIDS-CRAM, weighted. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1
#Excluded instruments: w2_PHQ2 , Pre-pandemic dep
@ Excluded instruments: w2_PHQ2, vaccine distrust, pandemic_dep, self-efficacy, risk perception, age, age squared, chronic illness, Household income pc, Schooling, African, Male, Married, Employed, Religious, Hunger, Socialmedia_info, Govt_info, Health_worker_info, News_info, Well-informed

Table A3 : First stage least square of vaccine attitudes estimation in Table 6

VARIABLES	w5_depression score
w2_PHQ2	**0.191*** **
	(0.0171)
Pre-pandemic dep	0.00403
	(0.00667)
Self-efficacy	-0.210**
	(0.0946)
Risk perception	0.443***
	(0.0570)
Age yrs	-0.00365
	(0.0106)
Age squared	-2.72e-05
	(0.000112)
Chronic illness	0.0623

	(0.0687)
Household income pc.	-0.0520**
	(0.0237)
Schooling yrs	0.00430
	(0.00839)
African	-0.490***
	(0.0892)
Male	-0.0153
	(0.0606)
Married	0.0376
	(0.0602)
Employed	-0.0202
	(0.0628)
Religious	0.284**
	(0.111)
Hunger	0.713***
	(0.0733)
socialmedia_info	0.0883
	(0.0954)
gov_info	-0.0810
	(0.0856)
health_worker_info	-0.0557
	(0.0879)
news_info	-0.0202
	(0.0731)
Well-informed	0.0782
	(0.0941)
Constant	1.760***
	(0.335)
F(20, 3509)	20.59***
Observations	3,530
R-squared	0.105

Source: NIDS-CRAM, weighted. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table A4: Heteroscedasticity based internal instrumental variable Lewbel regression results

	(1)	(2)	(3)
VARIABLES	**Vaccine distrust**	**Risk Perception**	**Perceived Efficacy**
Risk of depression#	0.271**	0.296***	-0.0326
	(0.121)	(0.0805)	(0.0536)
Risk perception	-0.100*		
	(0.0524)		
Self- Efficacy	-0.0816		
	(0.0711)		
African	-0.0576	0.0325	0.0739***
	(0.0677)	(0.0443)	(0.0275)
Male	0.0143	-0.000635	-0.00799
	(0.0459)	(0.0278)	(0.0155)
Age yrs	-0.00604**	0.00485***	0.000183
	(0.00240)	(0.00144)	(0.000811)
Above 60 years	0.0832	-0.248***	0.0120
	(0.0934)	(0.0558)	(0.0331)
Chronic illness	0.0166	-0.0133	-0.0281
	(0.0604)	(0.0318)	(0.0203)
Household income pc.	0.0131	0.0549***	-0.000114
	(0.0149)	(0.0112)	(0.00553)
School yrs	-0.00326	0.00929**	0.00306
	(0.00579)	(0.00370)	(0.00248)
Married	-0.0402	0.0856***	-0.0464***
	(0.0494)	(0.0282)	(0.0176)
Religious	-0.0952	-0.00929	-0.0322
	(0.0928)	(0.0463)	(0.0290)
hunger	0.00620	-0.0609	0.0275
	(0.0696)	(0.0398)	(0.0197)
socialmedia_info	0.235***	-0.00974	0.0189
	(0.0845)	(0.0385)	(0.0246)
gov_info	-0.0397	0.0513	0.00269
	(0.0597)	(0.0350)	(0.0207)

health_worker_info	-0.0544	0.0114	-0.0115
	(0.0575)	(0.0377)	(0.0246)
news_info	0.0119	0.0339	0.0105
	(0.0588)	(0.0324)	(0.0185)
Well informed	0.0496	0.0318	-0.0330
	(0.0895)	(0.0409)	(0.0286)
Constant	0.633***	-0.417***	0.859***
	(0.220)	(0.125)	(0.0791)
Hansen J	31.1	13.8	7.74
Observations	3,567	3,461	4,014
R-squared	0.015	0.073	0.023

Source: NIDS-CRAM, weighted. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1
Cut-off PHQ-2 ≥2

For further information please see **cramsurvey.org** and **nids.uct.ac.za**