How to increase acceptance of the COVID-19 vaccine among poor people in Africa?

Abstract:

This study aims to analyze whether good government management of the COVID-19 pandemic can increase the likelihood of vaccine uptake among poor people in Africa. The analysis is based on a sample of 18010 people living in 34 African countries, drawn from data collected by Afrobarometer (2022). The econometric results, obtained using a bivariate probit regression, show that poverty significantly reduces the odds of accepting the said COVID-19 vaccine. However, acceptance of the vaccine increases among poor individuals when there is (i) trust in the government's published statistics on COVID-19, (ii) control of corruption by the government in managing the pandemic, and (iii) individual confidence in the government's ability to ensure the safety of the COVID-19 vaccine, and (iv) assurance of the efficacy of the COVID-19 vaccine in relation to prayer.

Keywords: Poverty, COVID-19, vaccine, Africa

JEL code: I32, I39, I10, I11, I18

1. Introduction

This paper aims to analyze how good government management of the pandemic can increase the probability of accepting the COVID-19 vaccine among poor people in Africa. To achieve this goal, an ordered probit with an endogenous covariate was used and applied to Afrobarometer 2022 data. The rationale for this study is the importance of controlling the spread of COVID-19 in the context of achieving the Sustainable Development Goals (SDGs). The COVID-19 pandemic has sufficiently undermined the progress made by states towards sustainable development (Badré, 2020). It is a major obstacle to the full implementation of the United Nations 2030 Agenda, particularly in developing countries.

In developing countries, the prevalence of COVID-19 increases extreme poverty, widens income inequality, worsens unemployment, exacerbates hunger, and reverses progress in health and education (UN[1], 2021). About 32.02% of Africans have lost income due to the HIV/AIDS pandemic (Afrobarometer, 2022). The proportion of working poor in Africa has been steadily declining, from 49.10% (versus 26.1% globally) in 2000 to 31.9% (versus 6.7% globally) in 2019 (Ilostat, 2022). However, the COVID-19 pandemic has interrupted this downward trend. In 2020 and 2021, the global share of workers living with their families below the international poverty line increased for the first time since 2000, reaching 33.10% (vs. 7.2% globally)[2]. At the same time, the unemployment rate in Africa has risen steadily from 6.6% in 2010 to 7% in 2019 (Ilostat, 2022). However, the COVID-19 pandemic has exacerbated this, with unemployment rates in 2020 and 2021 increasing by 0.8 and 1.1 percentage points, respectively, compared to 2019 (Ilostat, 2022).

Some 118 countries have developed national strategies to fight COVID-19 pandemic (UN, 2021). Within this framework, nearly 1,600 short-term social protection measures have been introduced by governments (UN, 2021). However, more than 4 billion people still lack social protection (UN, 2021), and only 27.26% of people received humanitarian assistance during COVID-19. Other initiatives taken by governments include (i) closing land, air and sea borders (except for cargo flights and ships carrying essential goods and materials, whose stopovers will be limited and monitored), (ii) prohibiting public gatherings, (iii) postponing sports, school and university competitions, (iv) closing schools, (v) requisitioning private health facilities, hotels and other places of accommodation, vehicles, at the request of the competent authorities, (vi) suspension of the issuance of entry visas to Cameroon at the various airports, (vii) closure of drinking establishments, restaurants and places of entertainment, (viii) confinement[3], and (ix) scrupulous observance of the hygiene measures recommended by the World Health Organization, namely regular washing of hands with soap, avoidance of close contact such as shaking hands or kissing, covering the mouth when sneezing.

Africa represents about 17% of the world's population, but accounts for a quarter of the world's sick (WHO[4], 2018). It produces less than 2% of the medicines consumed on the continent (WHO, 2018). It receives only 1.3% of global health funding and has only 3% of the world's health workers (WHO, 2018). The progression of diseases in Africa is mainly due to the failure of the health systems set up in the countries, characterized in particular by the inadequacy of the infrastructure

[1] UN: United Nations
[2] Ilostat (2022)
[3] According to Afrobarometer (2022), about 44.16% of Africans have experienced confinement
[4] WHO: World Health Organization

of modern health facilities, the lack of qualified health personnel, the inadequacy of financial support for patients, and the proliferation of counterfeit medicines (Sambira, 2013; Jacquemot, 2020; Deml and Githaiga, 2022). Such a combination of shortcomings may explain why people in Africa are expected to live 11 years less than the global average in 2020 (World Bank, 2022). Despite these deficits, however, it is clear that the prevalence rate of COVID-19 in Africa is only 6.14% (Afrobarometer, 2022).

Vaccine hesitancy is considered a global health problem and is one of the 10 global health threats identified by the WHO in 2019 (WHO, 2019). COVID-19 vaccine hesitancy may undermine malaria immunization campaigns in Africa (Sulemana et al, 2022). The vaccination campaign in sub-Saharan Africa appears to be the slowest in the world, with two in 100 adults fully vaccinated, compared to a global average of over 30 in more advanced countries (UN, 2021). However, according to Rizk (2022), the COVAX program had 436 million doses available for allocation to low-income countries at the end of January 2022. However, low-income countries have requested only 100 million doses for distribution by the end of May 2022. This low demand for COVID-19 vaccine is partly due to limited capacity to manage stockpiles (by maintaining the cold chain) and vaccinate doses (by building distribution networks)[5].

In Africa, most studies have only examined vaccine uptake. Almost all of these studies have been conducted at the country level, including in South Africa (Kahn et al, 2022; Wiysonge et al, 2022; George et al, 2023), Burkina Faso (Faye et al, 2022), Cameroon (Dinda et al, 2021), Ethiopia (Dereje et al, 2022, Mose et al, 2022), Ghana (Acheampong et al, 2021 ; Alhassan et al, 2021), Guinea (Faye et al, 2022), Kenya (Orangi et al, 2021), Mali (Faye et al, 2022), Nigeria (Chutiyami et al, 2022), Senegal (Faye et al, 2022), Sierra Leone (Faye et al, 2022; Yendewa et al, 2022), Togo (Gbeasor-Komlanvi et al, 2021), Zambia (Carcelen et al, 2021). There is often heterogeneity among African countries in terms of culture, population, language, and economic and human development indicators. A few studies have examined the uptake of the COVID-19 vaccine in a panel of African countries: 15 countries for CDC Africa (2021), 5 countries for Wang et al (2022), and 31 countries for Osuagwu et al (2023). These authors did not examine the influence of the individual's standard of living on the acceptance of the COVID-19 vaccine. Their results do not allow general conclusions to be drawn due to the exclusion or underrepresentation of countries in certain regions of Africa. In addition, these three studies can be criticized for shortcomings in the representativeness of their samples. For example, the study by Osuagwu et al (2023) was conducted on the basis of online information about people from sub-Saharan Africa, whether they lived there or not. For example, almost 95% of the respondents in this study were from four countries (Nigeria, South Africa, Ghana, and Cameroon). Similarly, Wang et al (2022) studied only adolescents. CDC Africa (2021) did not perform econometric analysis, preferring univariate statistical methods. Vaccine hesitancy is complex and context-specific, varying by time, place, and type of vaccine (McDonald, 2015; Lazarus et al, 2022).

In addition, no econometric study has examined the impact of government management of the pandemic on vaccine acceptance in the areas of statistics, corruption, vaccine safety, and awareness of vaccine efficacy. Concerns about vaccine safety, corrupt practices, distrust of government statistics, and the spread of misinformation (including the effectiveness of religious prayer compared to the vaccine) emerged. Afrobarometer (2022) reported high levels of distrust among people living in Africa in the ability of authorities to provide a safe vaccine. Seydou (2021), using

[5] Rizk (2022)

Afrobarometer data from 5 countries, reports that among those who are "not at all confident" in the government's ability to ensure vaccine safety, only an average of 13% say they are "somewhat" or "very likely" to accept the vaccine, compared with 84% among those who are very confident in the government, a difference of 71 percentage points. In addition, about 65% of Africans believe that religious prayers are more effective than COVID-19 vaccines (Seydou, 2021). This proportion is 89% in Niger, 86% in Liberia, and 71% in Senegal. In these three countries, vaccine acceptance is low, ranging from 21% to 42%.

The interest of our study is to go beyond this by contributing to the debates on the acceptance of the COVID-19 vaccine (demand for care), which is one of the instruments in the fight against this pandemic. To fill the various gaps identified in the literature, we will use the Afrobarometer 2022 database of 34 African countries in our study. It includes countries from different regions of the African continent. Our sample is fairly representative of all African countries (63%)[6]. The population size of the countries in our sample represents more than 70% of Africa's total population[7]. Economically, the GDP per capita in our sample is USD 5,680 in purchasing power parity, while the average for sub-Saharan Africa is USD 4,069[8].

The response to these concerns is organized into four sections. The first section is devoted to the literature review. The second section describes the methodology used. The third section discusses the results, while the fourth section examines the econometric results.

2. Literature review

The demand for health theory developed by Grossman (1972) argues for the positive effect of increasing wages and family income on the demand for health and health care. Higher wages increase the opportunity cost of time lost to illness and may therefore induce workers to increase their health stock (measured by subjective health status) and substitute 'health goods and services' for time in the investment function. Empirical tests are not always confirmed. The empirical results of Grossman (1972) show that the health stock and the flow of health capital (measured by the number of "restricted activity" days and the number of sick days) increase significantly with the wage. On the other hand, the demand for health care (measured by health expenditure) decreases significantly as wages increase. This may imply that people with higher wages improve their health with inputs other than medical goods and services (better living, working and housing conditions).

With respect to family income, the empirical literature has produced mixed results. Grossman (1972) shows that income appears to be positively correlated with the consumption of care, but negatively correlated with the number of days in good health. To explain this paradox, Grossman (1975) puts forward the "joint production" hypothesis, according to which certain goods (alcohol, tobacco, excessively rich and caloric food) simultaneously produce "final satisfaction" in the consumer and a deterioration in the health stock. If the income elasticities of these goods are higher than those of health-promoting goods, the inverse correlation between income and health status is natural.

[6] See Table 4 in Annex
[7] Estimate based on World Bank statistics (2021)
[8] Estimate based on World Bank statistics (2021)

The empirical relationship between people's standard of living (income) and the demand for health care was studied before the COVID-19 pandemic. Some authors showed that the demand for health care was inelastic to income (while the majority of research reported an inelastic demand (Sauerborn et al, 1994). In this sense, some authors (Hsieh and Lin, 1997; Skordis-Worrall et al, 2011; Ali and Noman, 2013) find that individuals' income or salary does not significantly affect the demand for preventive or curative health care. On the other hand, other studies have shown that the demand for health care is income elastic. Thus, on the one hand, some authors have estimated an income elasticity greater than unity (Gerdtham et al, 1992; Wang, 2018), thus placing health care in the category of luxury goods. In the same vein, some authors have shown that an increase in income leads to an increase in the demand for preventive or curative health care (Kenkel, 1994; Mocan et al, 2004; Zhou et al, 2011; Burggraf et al, 2016; Pallegedara and Grimm, 2017). In the same vein, Mpabe (2021) shows that increasing the economic well-being of women in rural areas is likely to reduce the delay in HIV-AIDS testing compared to urban areas in Cameroon. On the other hand, other authors have found an income elasticity of less than one (Di Matteo and Di Matteo, 1998, Hitiris and Posnett 1992). No consensus has emerged in the empirical literature, and the debate on whether health care is a luxury good or not continues.

The debate about the influence of income or standard of living on the uptake of the COVID-19 vaccine is not clear-cut. Indeed, some studies show that people with higher incomes are less likely to accept the vaccine (Callaghan et al, 2021). On the other hand, other authors (Khubchandani et al, 2021; Allington et al, 2023) find that vaccine hesitancy decreases significantly with income. Other studies show that income does not significantly affect vaccine choice (Becerra and Becerra, 2022; Wiysonge et al, 2022). There are several reasons to explain this discrepancy in the results observed for COVID-19 vaccine uptake (Deml and Githaiga, 2022). These include (i) a lack of standardized and homogeneous approaches to measure vaccine hesitancy, vaccine acceptance, vaccine refusal or access to vaccines, (ii) unrepresentative study samples and insufficient nationally representative studies, and (iii) differences in sampling units.

For the first component, several indicators were used to measure vaccine acceptance or refusal. These include willingness to receive the COVID-19 vaccine (Chinawa et al, 2021; Mose et al, 2022), mothers' willingness to have their children vaccinated against COVID-19 (Chinawa et al, 2021), and individuals' willingness to receive the COVID-19 vaccine if it is available and donated (Kayanda et al, 2021). Some have focused on individuals' willingness to be vaccinated (Abebe et al, 2021; Mose et al, 2022; Wiysonge et al, 2022) and individuals' willingness to be vaccinated if the vaccine is available and free (Kassa Mekonnen et al, 2022).

With regard to the second component, most studies have used online surveys (Osuagwu et al., 2023). Although they have advantages[9], online surveys are subject to the same shortcomings or limitations as any self-administered survey, including lack of contact, sampling bias or sample non-representativeness, difficulty in effectively monitoring responses, and technological infrastructure limitations (Frippiat and Marquis, 2010; Jean, 2015). With regard to sampling bias, (i) certain categories or age groups remain difficult to reach via the Internet, (ii) when respondents are recruited via banners on a website, the profile of respondents depends on the website visited, the

[9] They allow for a significant reduction in the costs of a study, the time required and the risk of error. They also facilitate the collection of data in large geographical areas and open up new methodological perspectives (Frippiat & Marquis, 2010; Jean, 2015)

propensity to click on survey offers, and the extent of exposure to the banners, and (iii) voluntary response to the survey may be related to proximity to the person or structure initiating the survey. Due to the lack of contact, the respondent may misunderstand some questions and answers to open-ended questions may be poorly formulated and therefore not usable later. With regard to response control, it should be noted that in online surveys it is difficult to control the respondent profiles a priori, the samples obtained cannot always be validly adjusted and the same person may be tempted to respond several times if this is not controlled. As for the constraints related to the technological infrastructures, the interruptions observed.

For the third component, some authors used mothers (Chinawa et al, 2021) or individuals within the household (Sallam, 2021) as the sampling unit. In contrast, other authors focused only on health workers (Yilma et al, 2022) and adolescents (Wang et al, 2022).

3. Methodology

Data

The data for this study come from the Afrobarometer (2022) database. Information was collected in 34 African countries. The database consists of 48,084 individuals. Because our study focused on individuals who responded to questions about COVID-19 vaccine hesitancy, COVID-19 prevalence, and access to social networks, the sample size is 18,010 individuals.

Afrobarometer uses national probability samples, which are designed to be representative of all citizens of voting age in a given country. The goal is to give every adult citizen an equal and known chance of being selected for an interview. We achieve this by: (i) using random selection methods at each stage of the sampling process, and (ii) sampling at all stages with probability proportional to population size, wherever possible, to ensure that larger (i.e. more populous) geographical units have a proportionately higher chance of being selected for the sample.

The sample universe normally includes all citizens aged 18 and over. People living in institutions, such as students in dormitories, patients in hospitals, and people in prisons or nursing homes, are usually excluded. Sometimes people living in areas considered inaccessible due to conflict or insecurity are also excluded. The sample design is a multi-stage, stratified, clustered regional probability sample. Specifically, we first stratify the sample by the main subnational government unit (state, province, region, etc.) and by urban or rural location. Data are collected through face-to-face interviews with a sample of 1,200, 1,600 or 2,400 people in each country. The questions are identical across countries, allowing for systematic comparison. Trends in public opinion are tracked over time.

The Afrobarometer Network is an independent, non-partisan research project led by a number of organizations, including the CSD[10] , IDASA[11] and MSU[12] . Implemented through a network of national partners, Afrobarometer measures economic conditions and the political atmosphere in African countries. The questionnaire is standardized to facilitate cross-country comparisons. The countries covered by the 2022 surveys are listed in Table 4 in the Annex.

[10] CDD: Center for Democratic Development
[11] IDASA: Institute for Democracy in South Africa
[12] MSU: Michigan State University

Model specification

Several methods were used to identify explanatory factors for COVID-19 vaccine uptake: Bivariate statistics (Faly Ba et al, 2022; Kahn et al, 2022), logit or probit (Alhassan et al, 2021; Callaghan et al, 2021; Chutiyami et al, 2022; McElfish et al, 2021; Orangi et al, 2021; Becerra and Becerra, 2022; Dereje et al, 2022; Faye et al, 2022; Wang, 2022; Wiysonge et al, 2022), multinomial logit or probit (Acheampong et al, 2021; Gbeasor-Komlanvi et al, 2021; Khubchandani et al, 2021), ordinary least squares (Sato, 2022; Yendewa et al, 2022), log binomial regression (Carcelen et al, 2021; Wang et al, 2022), and hierarchical linear models (Allington et al, 2023). The shortcoming of these models is that they do not correct for endogeneity or simultaneity bias between poverty and COVID-19 vaccine uptake.

In view of the above, and given the nature of the variable that captures the acceptance of the COVID-19 vaccine and poverty, the choice of our econometric model was the recursive bivariate probit. It has the advantage of dealing with the endogeneity and simultaneity bias between poverty and COVID-19 vaccine uptake. The data we have do not provide information on the chronology of these two behaviors. Indeed, to illustrate, we do not know whether poverty precedes the adoption of the COVID-19 vaccine. However, the expression of a direct simultaneity between these two behaviors requires that this question be answered. The endogeneity of explanatory variables often poses difficulties in behavioral econometrics. The first doses of COVID-19 vaccine provided through the COVAX facility were administered in Africa in the first quarter of 2006. Most studies evaluated the vaccine for a short period after injection. According to the WHO[13], the efficacy of COVID-19 vaccines declines approximately 4-6 months after the first round of injections. If available, a booster dose is often recommended to increase the individual's protection against severe forms of the disease. UNICEF (2022) reports that some vaccinated individuals may be re-infected with COVID-19: this is a post-vaccination infection. In this situation, these individuals usually have only mild symptoms. The emergence of more infectious variants of COVID-19, such as the omicron variant, has led to an increase in post-vaccination infections (UNICEF, 2022). For this reason, WHO recommends continued adherence to barrier measures even after vaccination.

The endogeneity of explanatory variables often poses difficulties in behavioral econometrics. Theoretically, in the presence of endogeneity, the expectation of the error term conditional on the explanatory variable is non-zero and the usual estimators are subject to bias. To see this, consider the following simplified system:

$$\begin{cases} \theta^* = X_1\beta_1 + \varepsilon_1 \\ h^* = X_2\beta_2 + \gamma\theta + \varepsilon_2 \end{cases} \quad (1)$$

$$\text{With } \begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \end{pmatrix} \rightarrow N\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_1^2 & \rho\sigma_1\sigma_2 \\ \rho\sigma_1\sigma_2 & \sigma_2^2 \end{pmatrix}\right] \quad (2)$$

θ^* and h^* are two latent variables for which we observe :

$\theta = I(\theta^* > 0)$ and $h = I(h^* > 0)$. (3)

The conditional law of h^* knowing θ^* can therefore be written as follows:

$$h^* = X_2\beta_2 + \gamma\theta + \rho\frac{\sigma_2}{\sigma_1}(\theta^* - X_1\beta_1) + \mu \quad (4)$$

[13] Cited by UNICEF (2022)

The error term μ follows a normal distribution with a mathematical expectation of zero and a variance of $\sigma_1^2(1-\rho^2)$. As soon as $\rho \neq 0$it appears that $E(\varepsilon_2/X_2,\theta) \neq 0$. The autonomous estimation of the second equation of the initial system can therefore admit an endogeneity bias.

In the case of presumed causality between variables, when the explained variable and the explanatory variables are qualitative, the recursive bivariate probit model is very often used in the case of cross-sectional data (Lollivier, 2001). In the case of this model, Lollivier (2002) points out that "the use of a likelihood maximization procedure is practically unavoidable when the two variables[14] are qualitative".

In discrete variable models, problems of logical consistency make it difficult to express behaviors directly at the same time. In fact, one cannot introduce COVID-19 vaccine acceptance into the multidimensional poverty equation and multidimensional poverty as a determinant into the COVID-19 acceptance equation. One direction of the relationship should be preferred (Brunet and Havet, 2009).

For these reasons, and given the problem of this study, we chose to estimate a recursive bivariate probit[15] that allows us to simultaneously model the probability of being in a situation of poverty and its influence on the acceptance of the COVID-19 vaccine. The model chosen is recursive in the sense that the fact of being or not being in a situation of poverty is maintained as the predominant element in the equation for the acceptance of the COVID-19 vaccine. Furthermore, this model has the advantage of introducing a correlation between the error terms of the two equations (the multidimensional poverty equation and the COVID-19 vaccine acceptance equation). This makes it possible to control for unobserved heterogeneity that is likely to affect the estimation of the influence of certain socio-demographic and occupational characteristics.

Being poor and accepting the COVID-19 vaccine may be correlated in more than one way. The correlation may be positive if there are complementary links between these two behaviors. The correlation may also be negative if these two behaviors are more substitutes. Furthermore, it is conceivable that certain unobservable individual characteristics, such as the willingness to apply for a job or social assistance in a structure where knowledge of vaccination status is a conditionality, influence both the fact of being in a situation of poverty and the fact of accepting the COVID-19 vaccine, hence the potential correlations between these variables.

More specifically, the formal framework of the chosen specification is as follows:

$$Y_{i,PAUV} = \begin{cases} 1 & si\ Y^*_{i,PAUV} = Z_{ij}\gamma_{PAUV} + \mu_{i,PAUV} > 0 \\ 0 & si\ Y^*_{i,PAUV} = Z_{ij}\gamma_{PAUV} + \mu_{i,PAUV} \leq 0 \end{cases} \quad (5)$$

$$Y_{i,VCOV} = \begin{cases} 1 & si\ Y^*_{i,VCOV} = Y_{i,PAUV}\alpha + V_{ij}\gamma_{VCOV} + \mu_{i,VCOV} > 0 \\ 0 & si\ Y^*_{i,VCOV} = Y_{i,PAUV}\alpha + V_{ij}\gamma_{VCOV} + \mu_{i,VCOV} \leq 0 \end{cases} \quad (6)$$

Where the residuals ($\mu_{i,PAUV}$; $\mu_{i,VCOV}$) follow a bivariate joint normal distribution:

$$\begin{pmatrix} \mu_{i,PAUV} \\ \mu_{i,VCOV} \end{pmatrix} \rightarrow N\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \rho \\ \rho & 1 \end{pmatrix}\right] \quad (7)$$

[14] The variable to be explained and the explanatory variable.

[15] Read (Lollivier, 2001)

Where Z_{ij} represents the vector of explanatory variables for multidimensional poverty. V_{ij} is the vector of explanatory variables for COVID-19 vaccine acceptance. ρ is the correlation coefficient between the residuals.

Equations (5) and (6) model, respectively, the fact that the individual is in poverty ($Y_{i,PAUV} = 1$) and that he/she accepts to undergo the COVID-19 vaccine ($Y_{i,VCOV} = 1$). The parameter α captures the effect of poverty on the acceptance of the COVID-19 vaccine. Its sign is a priori indeterminate. Poverty in an environment of misinformation (fake news) and imperfect government management of the pandemic may or may not explain acceptance of the COVID-19 vaccine. γ_{PAUV} is the vector of coefficients of control variables that influence poverty. γ_{VCOV} is the vector of coefficients of control variables that influence COVID-19 vaccine acceptance.

This modeling will show whether these effects offset each other; if not, which one dominates. In order to estimate all the parameters, certain identification restrictions have to be imposed. As in all probit models, the variances of the residuals are not identifiable, so the first constraint is to normalize them to 1 (see equation 7). The only other constraint is imposed by the recursion of the model. Since the residuals of the latent equations are not independent, the parameters of the COVID-19 vaccine acceptance equation cannot be identified if the determinants of COVID-19 vaccine acceptance (V_{ij}) include all the determinants of multidimensional poverty (Z_{ij}). The identification constraint is that at least one of the explanatory variables in the multidimensional poverty equation is not included in the COVID-19 vaccine acceptance equation.

The log-likelihood associated with this model has the expression :

$$\ln L = \sum_{i=1}^{N} Y_{i,PAUV} Y_{i,VCOV} ln\left[\Phi_2(Z_{ij}\gamma_{PAUV}, \alpha + V_{ij}\gamma_{VCOV}; \rho)\right] + Y_{i,PAUV}(1 - Y_{i,VCOV}) ln\left[\Phi_2(Z_{ij}\gamma_{PAUV}, -\alpha - V_{ij}\gamma_{VCOV}; -\rho)\right] + \left(1 - Y_{i,PAUV}\right) Y_{i,VCOV} ln\left[\Phi_2\left(-Z_{ij}\gamma_{PAUV}, V_{ij}\gamma_{VCOV}; -\rho\right)\right] + (1 - Y_{i,PAUV})(1 - Y_{i,VCOV}) ln\left[\Phi_2(-Z_{ij}\gamma_{PAUV}, -V_{ij}\gamma_{VCOV}; \rho)\right] \quad (8)$$

With Φ_2 the distribution function of the standardised bivariate normal distribution. For example[16] :

$$\Phi_2\left(Z_{ij}\gamma_{PAUV}, \alpha + V_{ij}\gamma_{VCOV}; \rho\right) = \int_{-\infty}^{Z_{ij}\gamma_{PAUV}} \int_{-\infty}^{-\alpha - V_{ij}\gamma_{VCOV}} \phi_2(\mu_{i,PAUV}, \mu_{i,VCOV}, \rho) d_{\mu_{i,DEP}} d_{\mu_{i,VCOV}} \quad (9)$$

$$\text{With } \phi_2(\mu_{i,PAUV}, \mu_{i,VCOV}, \rho) = \left[1/2\pi(1-\rho^2)^{1/2}\right] exp\left[(-0,5(\mu_{i,PAUV}^2 + \mu_{i,VCOV}^2 - 2\rho\mu_{i,PAUV}\mu_{i,VCOV})/(1-\rho^2)\right] \quad (10)$$

$Y_{i,VCOV}$ indicates the probability of acceptance of the COVID-19 vaccine. It is a dichotomous variable that is represented as follows: 1 = if the individual is likely to receive the COVID-19 vaccine and 0 otherwise.

$\boldsymbol{Y_{i,PAUV}}$ gives information about the level of poverty. We use 7 poverty indicators. The first 5 are 5 deprivation indicators, each of which takes the value 1 if the individual has already experienced that deprivation and 0 otherwise. These are: deprivation in food (***FOOD***), deprivation in drinking water (***WATER***), deprivation in medical care (***MEDI***), deprivation in cooking equipment or fuel (***COOK***), and deprivation in cash income (***CASH***). The sixth indicator is the multidimensional poverty indicator (***PAUVM***) proposed by Afrobarometer, which is constructed from the five deprivation variables mentioned above. It initially takes the value 0 if the individual is not poor, 1 if his poverty level is low, 2 if his poverty level is moderate and 3 if his poverty level is high. In order to apply the apparently unrelated bivariate probit regression, this variable has been recoded

[16] See Brunet & Havet (2009)

into a dichotomous variable, as follows 1 if the person is in a situation of multidimensional poverty and 0 otherwise. The seventh indicator is the subjective poverty indicator (***POVSUB***) proposed by Afrobarometer. It initially takes the value 0 if the individual considers his living conditions to be very good, 1 if they are fairly good, 2 if they are neither good nor bad, 3 if they are fairly bad and 4 if they are very bad. In order to apply the recursive bivariate probit model, this variable was also recoded into a dummy variable as follows 1 if the individual thinks that living conditions are not good and 0 otherwise. The debate on the impact of poverty on vaccine uptake is not settled (Soares et al, 2021; Troiano and Nardi, 2021).

MCOV is the value that indicates the prevalence of COVID-19. It takes the value 1 if the individual has been affected by COVID-19 and 0 otherwise. Having a personal history of illness or having family members with illness may influence an individual's demand for health care. However, the effects appear to vary across studies (Dror et al, 2020; Soares et al, 2021; Troiano and Nardi, 2021).

CPEC is the variable that informs about the current economic conditions in the country of residence. It takes the value 0 if the individual considers them to be very bad, 1 if he/she considers them to be quite bad, 2 if he/she considers them to be neither bad nor good, 3 if he/she considers them to be quite good, and 4 if he/she considers them to be very good. The overall economic situation in the country of residence may affect vaccine uptake. However, its effects vary across studies (Troiano and Nardi, 2021).

SOME is the variable that indicates whether the individual is informed about social networks. It takes the value 0 if the individual never connects to social networks, 1 if he/she connects to social networks less than once a month, 2 if he/she connects to social networks a few times a month, 3 if he/she connects to social networks a few times a week and 4 if he/she connects to social networks every day. Razai et al (2021) show that spreading misinformation about COVID-19 can reduce the chances of vaccine acceptance.

BRCOV is the variable that provides information on income loss due to COVID-19. It has a value of 1 if yes and 0 if no. Soares et al (2021) use bivariate statistics to show that people who have lost income due to Covid-19 are more likely to accept the vaccine.

TSTAT is the variable that indicates confidence in the government's COVID-19 statistics. It has a value of 0 if the individual has no confidence at all in the government's COVID-19 statistics, 1 if he/she has some confidence, 2 if he/she has some confidence, and 3 if he/she has a lot of confidence. Lucia et al (2021) believe that people who have more information about the COVID-19 pandemic are more likely to accept the vaccine.

CCOV is the variable that provides information on the perception of corruption related to COVID-19. It takes the value 0 if the individual thinks there is a lot of corruption related to COVID-19, 1 if he/she thinks there is enough corruption related to COVID-19, 2 if he/she thinks there is some corruption related to COVID-19, and 3 if he/she thinks there is no corruption related to COVID-19. Razai et al (2021) show that low trust in government reduces the likelihood of accepting the COVID-19 vaccine.

TSVCOV is the variable that informs about the individual's confidence in the government's ability to ensure the safety of COVID-19 vaccines. It has a value of 0 if he/she is not at all confident, 1 if he/she is somewhat confident, 2 if he/she is somewhat confident, and 3 if he/she is very confident.

Some authors (Dror et al, 2020; Razai et al, 2021) believe that guaranteeing the quality and safety of the COVID-19 vaccine may lead to its acceptance by individuals.

EPCOV is the variable that provides information on the effectiveness of prayer compared to COVID-19 vaccines. It takes the value 0 if the individual believes that prayer is much more effective than COVID-19 vaccines, 1 if he/she believes that it is somewhat more effective than COVID-19 vaccines, 2 if he/she believes that prayer and COVID-19 vaccines are equally effective, 3 if he/she believes that prayer is somewhat less effective than COVID-19 vaccines, and 4 if he/she believes that prayer is much less effective than COVID-19 vaccines. Some authors (Dror et al, 2020; Lucia et al, 2021; Soares et al, 2021) use statistical methods to show that people who believe in the efficacy of the COVID-19 vaccine are more likely to accept it.

COVF is the variable that indicates the perception of the severity of the COVID-19 pandemic in the future (within the next 6 months). It has a value of 0 if the individual thinks the pandemic will not be severe at all, 1 if they think it will not be very severe, 2 if they think it will be somewhat severe, and 3 if they think it will be very severe. Lucia et al (2021) argue that people with high exposure to COVID-19 are more likely to accept the vaccine.

SEX is the variable that indicates the sex of the individual. It takes the value 1 if he is a man and 0 if he is a woman. Gender may influence COVID-19 vaccine uptake. However, its effect appears to vary across studies (Dror et al, 2020; Soares et al, 2021; Troiano and Nardi, 2021).

ZON is the variable that informs about the place of residence of the individual. It takes the value 1 if he/she lives in an urban area and 0 if he/she lives in a rural area. A person's place of residence may influence the uptake of the COVID-19 vaccine. However, its effect appears to vary across studies (Troiano and Nardi, 2021).

AGE is the variable that indicates the age of the individual. It is a quantitative variable. The age of the individual may influence the acceptability of the COVID-19 vaccine. However, its effect appears to vary from study to study (Dror et al, 2020; Soares et al, 2021; Troiano and Nardi, 2021).

EDU is the variable that makes it possible to assess the level of education of the individual. It has a value of 0 if he/she is illiterate, 1 if he/she has primary education, 2 if he/she has secondary education and 3 if he/she has higher education. An individual's level of education may influence acceptance of the COVID-19 vaccine. However, its effect appears to vary from study to study (Lucia et al, 2021; Soares et al, 2021; Troiano and Nardi, 2021).

REL is the variable that informs about the religious affiliation of the individual. It takes the value 2 if he is Muslim, 1 if he is Christian and 0 in the opposite case. Religious affiliation may influence acceptance of the COVID-19 vaccine. However, its effects appear to vary from study to study (Troiano and Nardi, 2021).

EMPL is the variable that informs about the employment status of the individual. It takes the value 0 if the person is unemployed and not looking for a job, 1 if the person is employed, 2 if the person works part-time and 3 if the person works full-time. An individual's occupational status may influence uptake of the COVID-19 vaccine. However, its effects appear to vary from study to study (Soares et al, 2021; Troiano and Nardi, 2021).

Looking at Table 1, less than half of Africans are willing to accept the COVID-19 vaccine (48%) and 6.20% of Africans have been infected with COVID-19. In addition, 89.20% of Africans live in poverty and 69.90% are unemployed. About 71% of people think that the economic conditions in their country of residence are not good.

Table 1: Descriptive statistics

Variables	Number of observation	Average	Standard deviation	Minimum	Maximum
VCOV					
No	18,010	0.520	0.500	0	1
Yes	18,010	0.480	0.500	0	1
PAUVM					
Not poor	17,892	0.108	0.311	0	1
Poor	17,892	0.892	0.311	0	1
FOOD					
No	18,002	0.601	0.490	0	1
Yes	18,002	0.399	0.490	0	1
WATER					
No	17,999	0.567	0.496	0	1
Yes	17,999	0.433	0.496	0	1
MEDI					
No	17,950	0.510	0.500	0	1
Yes	17,950	0.490	0.500	0	1
COOK					
No	17,986	0.658	0.475	0	1
Yes	17,986	0.342	0.475	0	1
CASH					
No	17,985	0.347	0.476	0	1
Yes	17,985	0.653	0.476	0	1
POVSUB					
No	17,989	0.365	0.481	0	1
Yes	17,989	0.635	0.481	0	1
CPEC					
Very bad	17,888	0.342	0.474	0	1
Quite bad	17,888	0.264	0.441	0	1
Neither good nor bad	17,888	0.104	0.305	0	1
Fairly good	17,888	0.225	0.418	0	1
Very good	17,888	0.065	0.247	0	1
SEX					
Woman	18,010	0.498	0.500	0	1
Male	18,010	0.502	0.500	0	1
EDU					
Illiterate	17,969	0.189	0.392	0	1
Primary education	17,969	0.231	0.421	0	1
Secondary education	17,969	0.392	0.488	0	1
Higher education	17,969	0.188	0.391	0	1
REL					
Other	18,010	0.111	0.314	0	1
Christians	18,010	0.486	0.500	0	1
Muslims	18,010	0.403	0.491	0	1
EMPL					
Passive unemployment	17,973	0.417	0.493	0	1

Active unemployment	17,973	0.273	0.445	0	1
Part-time work	17,973	0.131	0.337	0	1
Full-time work	17,973	0.180	0.384	0	1
ZON					
Rural area	18,010	0.551	0.497	0	1
Urban area	18,010	0.449	0.497	0	1
AGE	18,007	36.633	14.475	18	115
SOME					
Never	17,904	0.432	0.495	0	1
Less than once a month	17,904	0.033	0.177	0	1
A few times a month	17,904	0.050	0.218	0	1
A few times a week	17,904	0.136	0.343	0	1
Every day	17,904	0.349	0.477	0	1
MCOV					
Not sick	17,989	0.938	0.241	0	1
Sick	17,989	0.062	0.241	0	1
BRCOV					
No	17,985	0.680	0.467	0	1
Yes	17,985	0.320	0.467	0	1
LDSCOV					
Not at all in agreement	14,328	0.073	0.260	0	1
No agreement	14,328	0.113	0.317	0	1
Neither agree nor disagree	14,328	0.042	0.200	0	1
I agree.	14,328	0.449	0.497	0	1
Totally agree	14,328	0.323	0.468	0	1
SCSCOV					
Strongly opposed	17,965	0.156	0.363	0	1
Quite opposite	17,965	0.151	0.358	0	1
Neither opposed nor supportive	17,965	0.050	0.219	0	1
Provides sufficient support	17,965	0.280	0.449	0	1
Strongly supports	17,965	0.363	0.481	0	1
RAHCOV					
No	16,488	0.723	0.447	0	1
Yes	16,488	0.277	0.447	0	1
DAHCOV					
Very unfair	15,124	0.468	0.499	0	1
Quite inequitable	15,124	0.205	0.404	0	1
Neither fair nor unfair	15,124	0.114	0.317	0	1
Fair enough	15,124	0.126	0.332	0	1
Very fair	15,124	0.088	0.283	0	1
TSTAT					
No confidence at all	17,638	0.331	0.471	0	1
A little confidence	17,638	0.282	0.450	0	1
Fairly confident	17,638	0.221	0.415	0	1
A lot of confidence	17,638	0.166	0.372	0	1
CCOV					
A lot of corruption	15,668	0.492	0.500	0	1
Enough corruption	15,668	0.283	0.450	0	1
Little corruption	15,668	0.152	0.359	0	1
No corruption	15,668	0.072	0.259	0	1
TSVCOV					
No confidence at all	17,626	0.353	0.478	0	1
A little confidence	17,626	0.267	0.442	0	1
Fairly confident	17,626	0.209	0.407	0	1

A lot of trust	17,626	0.171	0.377	0	1
EPCOV					
Much less effective	17,560	0.409	0.492	0	1
Slightly less effective	17,560	0.199	0.399	0	1
As effective	17,560	0.161	0.367	0	1
A little more efficient	17,560	0.120	0.325	0	1
Much more efficient	17,560	0.112	0.315	0	1
COVF					
Not at all serious	17,023	0.294	0.456	0	1
Not very serious	17,023	0.286	0.452	0	1
A bit serious	17,023	0.229	0.420	0	1
Very serious	17,023	0.190	0.393	0	1

Looking at Table 2, the proportion of people who consider their acceptance of the vaccine likely is 65.92% among non-poor people and 45.91% among poor people. This suggests that the level of acceptance of the COVID-19 vaccine decreases with the level of multidimensional poverty. Similarly, the level of acceptance of the vaccine decreases with the level of food insecurity and monetary poverty.

In addition, the proportion of individuals who consider it "likely" that they will accept the vaccine is 51.98% among people with COVID-19 compared to 47.78% among those without the disease. Thus, people with COVID-19 are likely to choose vaccination.

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Table 2: Bivariate statistics (in %)

	VCOV				
	No	**Yes**	**Total**	**Pearson test**	**Proportion likely to accept the COVID-19 vaccine**
PAUV					
Not poor	3.680	7.140	10.830		65.928
Poor	48.230	40.940	89.170	Chi2 = 278.658***	45.912
POVSUB					
Not poor	17.510	18.970	36.480		52.001
Poor	34.450	29.070	63.520	Chi2 = 65.079***	45.765
FOOD					
No	29.150	30.970	60.120		51.514
Yes	22.810	17.060	39.880	Chi2 = 131.454***	42.778
WATER					
No	27.640	29.040	56.680		51.235
Yes	24.310	19.010	43.320	Chi2 = 95.884***	43.883
MEDI					
No	24.260	26.780	51.040		52.469
Yes	27.670	21.290	48.960	Chi2 = 144.759***	43.484
COOK					
No	32.480	33.280	65.760		50.608
Yes	19.470	14.770	34.240	Chi2 = 90.399***	43.137
CASH					
No	15.710	18.970	34.680		54.700
Yes	36.260	29.060	65.320	Chi2 = 170.125***	44.489
MCOV					
Not sick	49	44.84	93.840		47.783

Sick	2.970	3.200	6.160	Chi2 = 6.886***	51.984

NB: *** represents significance at 1%.

4. Results

We analyze the econometric results in Table 3 below. The correlation coefficient $\rho_{PAUV,VCOV}$ between the Internet access equation and the HIV-AIDS testing equation is statistically significant at the 1% level. Some unobservable individual characteristics simultaneously affect a woman's probability of being poor and of accepting the COVID-19 vaccine. This suggests that the probability of being poor positively affects the probability of accepting the COVID-19 vaccine and vice versa. Thus, there may be complementary relationships between poverty and vaccine uptake. Therefore, it seems useful to estimate these two equations simultaneously using a recursive bivariate probit.

Table 3: Econometric results of the bivariate probit (direct effects)

	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6		Model 7	
	PAUVM		CASH		FOOD		MEDI		WATER		COOK		POVSUB	
	Coef.	Std.Err.	Coef.	Std.Err.	Coef.	Std.Err.	Coef.	Std.Err.	Coef.	Std.Err.	Coef.	Std.Err.	Coef.	Std.Err.
	acceptance of the COVID-19 vaccine equation (VCOV)													
PAUV (ref: Not poor or no deprivation)	-1.538***	0.076	-1.437***	0.053	-1.409***	0.061	-1.371***	0.057	-1.484***	0.042	-1.380***	0.056	-1.466***	0.044
CPEC (ref: Very poor)														
Quite bad	0.062	0.038	-0.030	0.035	-0.079**	0.036	-0.054	0.035	0.012	0.034	-0.036	0.035	-0.003	0.035
Neither bad nor good	0.070	0.052	-0.025	0.049	-0.076	0.050	-0.092	0.049	-0.042	0.047	0.002	0.049	-0.015	0.048
Fairly good	0.078*	0.042	-0.043	0.040	-0.062	0.041	-0.091**	0.041	0.026	0.037	0.034	0.039	-0.488***	0.044
Very good	-0.045	0.066	-0.166***	0.062	-0.078	0.062	-0.139**	0.062	-0.021	0.059	-0.055	0.061	-0.748***	0.065
SEX (ref: Female)	0.074**	0.030	0.057**	0.028	0.007	0.028	0.056**	0.028	0.054**	0.027	0.019	0.028	0.053*	0.027
EDU (ref: Illiterate)														
Primary education	0.114**	0.050	0.011	0.046	-0.018	0.046	-0.054	0.046	-0.016	0.044	-0.147***	0.046	0.150***	0.046
Secondary education	0.082*	0.050	-0.068	0.045	-0.095**	0.045	-0.131***	0.045	-0.079*	0.043	-0.196***	0.045	0.075*	0.045
Higher education	0.066	0.059	-0.104*	0.055	-0.154***	0.055	-0.148***	0.055	-0.074	0.052	-0.211***	0.055	0.017	0.053
REL (ref: Other religions)														
Christians	0.131**	0.059	0.077	0.051	-0.125**	0.050	-0.013	0.052	-0.051	0.046	-0.177***	0.047	-0.020	0.046
Muslims	0.010	0.061	0.112**	0.057	-0.273***	0.052	0.029	0.058	-0.165***	0.048	-0.275***	0.050	-0.115**	0.049
EMPL (ref: Unemployed and not looking for work)														
Unemployment	0.083**	0.038	0.078**	0.036	0.059*	0.036	0.020	0.035	0.013	0.034	0.022	0.035	0.038	0.035
Part-time work	-0.046	0.046	-0.099**	0.043	-0.083*	0.043	-0.104**	0.043	-0.044	0.042	-0.066	0.043	-0.060	0.043
Full-time work	-0.052	0.042	-0.134***	0.040	-0.047	0.040	-0.057	0.039	-0.016	0.038	-0.020	0.039	-0.026	0.039
ZON (ref: Rural area)	-0.122***	0.031	-0.150***	0.029	-0.141***	0.029	-0.204***	0.029	-0.216***	0.028	-0.081***	0.029	-0.068**	0.029
AGE	0.003***	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.001	-0.001	0.001	0.004***	0.001
SOME (ref: Never)														
Less than once a month	-0.035	0.083	0.027	0.079	-0.059	0.079	-0.073	0.078	-0.036	0.076	-0.007	0.078	-0.123	0.077
A few times a month	-0.101	0.070	-0.007	0.066	-0.068	0.066	-0.083	0.065	-0.067	0.063	-0.047	0.066	-0.107*	0.064
A few times a week	-0.050	0.048	-0.040	0.045	-0.101**	0.045	-0.115***	0.044	-0.045	0.043	-0.054	0.044	-0.067	0.044
Every day	-0.195***	0.040	-0.187***	0.037	-0.241***	0.037	-0.233***	0.037	-0.168***	0.036	-0.126***	0.037	-0.137***	0.036
MCOV (ref: not sick)	0.030	0.054	0.013	0.046	0.032	0.047	0.029	0.047	0.029	0.043	0.041	0.046	0.017	0.045
BRCOV (ref: No)	0.069**	0.031	0.131***	0.029	0.047	0.029	0.084***	0.029	0.055**	0.028	0.035	0.029	0.067**	0.028
LDSCOV (ref: Strongly disagree)														
No agreement	-0.166**	0.065	-0.187***	0.056	-0.217***	0.057	-0.197***	0.056	-0.165***	0.052	-0.208***	0.055	-0.190***	0.053
Neither agree nor disagree	-0.281***	0.086	-0.283***	0.075	-0.308***	0.076	-0.283***	0.075	-0.252***	0.068	-0.299***	0.074	-0.255***	0.072
I agree.	-0.115**	0.055	-0.143***	0.048	-0.169***	0.049	-0.152***	0.048	-0.126***	0.044	-0.168***	0.047	-0.127***	0.046
Totally agree	-0.039	0.056	-0.071	0.048	-0.078	0.049	-0.076	0.048	-0.044	0.044	-0.080*	0.047	-0.055	0.046
SCSCOV (ref: strongly opposed														
Quite opposite	-0.114**	0.052	-0.112**	0.045	-0.113**	0.045	-0.118***	0.044	-0.096**	0.041	-0.120***	0.044	-0.101**	0.043
Neither opposed nor supportive	-0.041	0.075	-0.028	0.066	-0.020	0.066	-0.023	0.065	-0.016	0.060	-0.019	0.065	-0.015	0.063
Provides sufficient support	0.060	0.046	0.039	0.040	0.040	0.040	0.044	0.040	0.039	0.036	0.032	0.039	0.049	0.038
Strongly supports	0.110**	0.044	0.093**	0.038	0.090**	0.038	0.098***	0.038	0.085**	0.034	0.086**	0.037	0.105***	0.036
DAHCOV (ref: Very unfair)														
Quite inequitable	0.041	0.038	0.037	0.033	0.048	0.033	0.036	0.033	0.045	0.030	0.045	0.033	0.035	0.032
Neither fair nor unfair	0.050	0.048	0.042	0.042	0.074*	0.042	0.060	0.042	0.054	0.039	0.068	0.042	0.070*	0.040

Fair enough	0.034	0.047	0.047	0.041	0.053	0.041	0.050	0.041	0.053	0.037	0.044	0.040	0.042	0.039
Very fair	-0.113**	0.054	-0.084*	0.047	-0.090*	0.047	-0.086*	0.046	-0.072*	0.043	-0.084*	0.046	-0.090**	0.045
TSTAT (ref: not at all confident)														
a little confidence	0.136***	0.038	0.120***	0.033	0.113***	0.033	0.112***	0.033	0.097***	0.030	0.109***	0.032	0.105***	0.032
enough confidence	0.251***	0.042	0.224***	0.037	0.226***	0.038	0.218***	0.037	0.204***	0.034	0.222***	0.037	0.211***	0.035
a lot of confidence	0.334***	0.050	0.295***	0.043	0.298***	0.044	0.289***	0.043	0.268***	0.040	0.291***	0.043	0.274***	0.042
CCOV (ref: much corruption)														
Enough corruption	-0.036	0.035	-0.029	0.030	-0.025	0.030	-0.028	0.030	-0.023	0.027	-0.016	0.030	-0.022	0.029
Little corruption	0.150***	0.045	0.134***	0.039	0.144***	0.039	0.132***	0.039	0.121***	0.036	0.144***	0.039	0.137***	0.037
No corruption	0.261***	0.070	0.223***	0.060	0.230***	0.061	0.210***	0.060	0.218***	0.056	0.225***	0.060	0.224***	0.058
TSVCOV (ref: does not trust at all)														
Has some confidence	0.788***	0.037	0.668***	0.035	0.673***	0.037	0.663***	0.035	0.618***	0.033	0.654***	0.035	0.654***	0.033
Is fairly confident	1.271***	0.043	1.105***	0.045	1.123***	0.048	1.105***	0.046	1.016***	0.043	1.089***	0.046	1.082***	0.040
Has a lot of confidence	1.816***	0.056	1.583***	0.060	1.630***	0.064	1.585***	0.063	1.465***	0.060	1.589***	0.062	1.553***	0.053
EPCOV (ref: much less effective)														
a little less efficient	0.016	0.039	0.024	0.033	0.021	0.034	0.018	0.033	0.014	0.031	0.015	0.033	0.018	0.032
equally effective	0.173***	0.041	0.164***	0.036	0.169***	0.036	0.165***	0.036	0.155***	0.033	0.164***	0.035	0.162***	0.034
A little more efficient	0.190***	0.046	0.175***	0.040	0.181***	0.040	0.166***	0.040	0.155***	0.037	0.166***	0.040	0.162***	0.038
much more effective	0.300***	0.051	0.272***	0.044	0.271***	0.045	0.259***	0.044	0.242***	0.041	0.256***	0.044	0.253***	0.043
COVF (ref: not at all serious)														
Not very serious	0.108***	0.039	0.089***	0.033	0.082**	0.034	0.084**	0.033	0.085***	0.031	0.084**	0.033	0.091***	0.032
A bit serious	-0.035	0.041	-0.030	0.036	-0.037	0.036	-0.037	0.035	-0.022	0.033	-0.029	0.035	-0.028	0.034
Very serious	-0.012	0.043	-0.030	0.037	-0.034	0.037	-0.036	0.037	-0.018	0.034	-0.021	0.036	-0.006	0.035
	Determinants of poverty or deprivation (PAUV) equation													
CPEC (ref: Very poor)														
Quite bad	-0.075	0.048	-0.185***	0.035	-0.260***	0.034	-0.228***	0.034	-0.065**	0.033	-0.185***	0.034	-0.135***	0.035
Neither bad nor good	-0.251***	0.062	-0.301***	0.048	-0.376***	0.048	-0.418***	0.047	-0.284***	0.047	-0.239***	0.048	-0.261***	0.048
Fairly good	-0.508***	0.047	-0.479***	0.037	-0.523***	0.037	-0.572***	0.037	-0.276***	0.036	-0.338***	0.037	-1.234***	0.038
Very good	-0.396***	0.075	-0.425***	0.061	-0.242***	0.061	-0.379***	0.060	-0.119**	0.059	-0.216***	0.061	-1.504***	0.065
SEX (ref: Female)	0.210***	0.036	0.097***	0.028	-0.006	0.028	0.098***	0.027	0.068**	0.027	0.019	0.028	0.072**	0.028
EDU (ref: Illiterate)														
Primary education	0.123**	0.059	-0.138***	0.045	-0.185***	0.043	-0.260***	0.043	-0.174***	0.042	-0.434***	0.044	0.149***	0.045
Secondary education	0.189***	0.056	-0.204***	0.043	-0.250***	0.042	-0.326***	0.042	-0.198***	0.041	-0.447***	0.042	0.081*	0.043
Higher education	-0.086	0.065	-0.394***	0.052	-0.516***	0.053	-0.500***	0.052	-0.306***	0.051	-0.624***	0.053	-0.159***	0.053
REL (ref: Other religions)														
Christians	1.173***	0.047	0.664***	0.041	0.335***	0.042	0.555***	0.042	0.315***	0.040	0.223***	0.042	0.438***	0.041
Muslims	0.897***	0.050	0.800***	0.043	0.116***	0.044	0.712***	0.044	0.178***	0.042	0.108	0.044	0.307	0.043
EMPL (ref: Unemployed and not looking for work)														
Unemployment	0.569***	0.051	0.231***	0.035	0.165***	0.034	0.096***	0.034	0.050	0.033	0.102***	0.034	0.137***	0.035
Part-time work	0.107*	0.056	-0.054	0.043	-0.018	0.043	-0.051	0.042	0.029	0.041	0.019	0.043	0.023	0.044
Full-time work	-0.261***	0.046	-0.334***	0.038	-0.205***	0.040	-0.201***	0.039	-0.112***	0.038	-0.141***	0.040	-0.126***	0.039
ZON (ref: Rural area)	-0.189***	0.038	-0.174***	0.029	-0.151***	0.029	-0.270***	0.029	-0.269***	0.028	-0.034	0.029	-0.023	0.030
AGE	0.006	0.001	0.000	0.001	0.000	0.001	0.001	0.001	-0.002**	0.001	-0.004***	0.001	0.006***	0.001

SOME (ref: Never)														
Less than once a month	0.087	0.111	0.215***	0.083	0.036	0.078	-0.013	0.077	0.056	0.076	0.111	0.078	-0.139*	0.081
A few times a month	0.214**	0.100	0.292***	0.069	0.133**	0.064	0.074	0.064	0.091	0.063	0.148**	0.065	-0.016	0.066
A few times a week	0.058	0.062	0.063	0.045	-0.063	0.044	-0.109**	0.044	0.021	0.043	0.018	0.044	-0.020	0.045
Every day	-0.287***	0.048	-0.164***	0.036	-0.283***	0.036	-0.260***	0.036	-0.135***	0.035	-0.059	0.037	-0.099***	0.037
BRCOV (ref: No)	0.321***	0.038	0.292***	0.028	0.138***	0.028	0.199***	0.028	0.122***	0.027	0.118***	0.028	0.169***	0.029
RAHCOV (ref: No)	0.112***	0.038	0.141***	0.028	0.072***	0.028	0.071***	0.027	0.056**	0.026	0.072***	0.028	0.103***	0.028
/athrho	0.784***	0.079	1.064***	0.088	0.987***	0.094	1.030	0.092	1.279***	0.105	1.054***	0.092	1.246***	0.083
rho	0.655	0.045	0.787	0.034	0.756	0.040	0.774	0.037	0.856	0.028			0.847	0.024
Wald test of rho=0 :	97.371***		144.632***		109.510***		124.093***		148.278***		131.916***		222.892***	

NB: ***, ** and * represent significance at 1%, 5% and 10% respectively

5. Discussions

The coefficient of the variable "***PAUV***" is negative and significant in the "***VCOV***" equations of models 1, 8, 9, 10, 11 and 12. This shows that people in multidimensional poverty are less willing to accept the COVID-19 vaccine. Our result is in contrast to some authors who argue that (i) people with high income are less likely to choose the COVID-19 vaccine (Callaghan et al, 2021) and (ii) income does not significantly influence vaccine choice (Becerra and Becerra, 2022; Wiysonge et al, 2022). People who have difficulty accessing the COVID-19 vaccine are less likely to accept vaccination (Orangi et al, 2021; Wiysonge et al, 2022). Our results also show that the other deciles of poverty (deprivation of monetary resources, food insecurity, deprivation of drinking water, deprivation of internal cooking facilities, deprivation of health care) have similar effects on vaccine acceptance (see models 2 to 7). Our results show that in the face of the COVID-19 pandemic, the most deprived people were more likely to turn to traditional medicine, especially herbal medicine.

In model 1, the coefficient of the "fairly good" modality of the "***CPEC***" variable is positive and significant in the "***VCOV***" equation. This shows that people who rate the economic conditions of their country of residence as "fairly good" are more likely to choose the COVID-19 vaccine. On the other hand, in models 4 and 7, the coefficient of this modality becomes negative and significant in the "VCOV" equation. In models 2, 3, 5 and 6 it is insignificant. All this shows that the influence of the country's economic conditions on vaccine acceptance varies according to the type of deprivation or poverty.

The coefficient of the variable "***BRCOV***" is positive and significant in models 1, 2, 4, 5 and 7. This indicates that individuals who have experienced income loss due to COVID-19 are more likely to accept the vaccine. The loss of income may be difficult to bear for individuals who do not have a savings cushion or family allowance to help them absorb the shock. Under these circumstances, they feel that the vaccine alone can help them resume their activities with peace of mind.

In models 1 to 3, the coefficient of the "active unemployment" modality is positive and significant in the "***VCOV***" equation. Consequently, unemployed people are more willing to accept the COVID-19 vaccine. Our result is not consistent with that obtained by some authors (Khubchandani et al, 2021). On the other hand, the influence of this modality is not significant in models 4 to 6.

The sign of the "***AGE***" variable is positive and significant in the "***VCOV***" equation of models 1 and 7. This indicates that older people are more likely to have COVID-19 and to accept the COVID-19 vaccine. Our results are consistent with some studies (Acheampong et al, 2021; Gbeasor-Komlanvi et al, 2021; McElfish et al, 2021; Wiysonge et al, 2022; Allington et al, 2023). On the other hand, they do not confirm those of authors showing that (i) acceptance of the COVID-19 vaccine significantly decreases with age (Alhassan et al, 2021; Callaghan et al, 2021; Dereje et al, 2022) and (ii) age does not significantly influence vaccine hesitancy (Khubchandani et al, 2021). Our results express the willingness of the elderly to compensate for the natural depreciation of their health capital by increasing investment.

The coefficients of the modalities of the "***EDU***" variable are positive and significant in the "***VCOV***" equation of models 1 and 7. This shows that COVID-19 prevalence and vaccine acceptance increase with people's level of education. However, our result on health care demand shows that

formal education can facilitate the use of rational approaches by individuals in making health care decisions compared to traditional approaches. This may increase the awareness and commitment of educated people to follow public health recommendations. On the other hand, these coefficients are negative and significant in models 2 to 6. This indicates that the effect of education on vaccine uptake varies by type of deprivation or poverty. Some studies have shown that education does not influence the choice of COVID-19 vaccine (Alhassan et al, 2021; Acheampong et al, 2021; Dereje et al, 2022). In contrast, other authors (Callaghan et al, 2021; McElfish et al, 2021) show that educated people are less likely to choose this vaccine. On the other hand, some authors (Khubchandani et al, 2021; Allington et al, 2023) argue that vaccine uptake increases significantly with education.

In the equation "***VCOV***" of models 1, 2, 4, 5 and 7, the coefficient of the variable "***SEX***" is positive and significant. This shows that men are more willing to accept the COVID-19 vaccine. Our result is in line with that obtained by some authors (Alhassan et al, 2021; Callaghan et al, 2021; Gbeasor-Komlanvi et al, 2021; Khubchandani et al, 2021; McElfish et al, 2021; Dereje et al, 2022; Allington et al, 2023). On the other hand, it is not consistent with some studies showing that gender does not significantly influence preference for the COVID-19 vaccine (Acheampong et al, 2021; Becerra and Becerra, 2022; Yendewa, 2022; Wiysonge et al, 2022).

The coefficient of the "Christian" modality of the "***REL***" variable is positive and significant in the "***VCOV***" equation of Model 1. This shows that Christians are more likely to be vaccinated. On the other hand, the coefficient of this modality is negative and significant in models 3 and 6. Thus, we can see that the influence of religious affiliation on vaccine acceptance varies according to the type of deprivation or poverty. Some authors (Alhassan et al, 2021; Dereje et al, 2022; Wiysonge et al, 2022) show that religion does not significantly influence the uptake of the COVID-19 vaccine. Some authors (Orangi et al, 2021; Wiysonge et al, 2022) show that religious and cultural norms significantly influence COVID-19 vaccine refusal. Some studies show that people with high levels of religiosity are less likely to choose the COVID-19 vaccine (Callaghan et al, 2021).

The coefficient of the "*Every day*" modality of the "***SOME***" variable is negative and significant in the "***VCOV***" equation in models 1 to 7. Consequently, people who consume information through social networks every day are less inclined to accept the COVID-19 vaccine. Our results on COVID-19 vaccine acceptance are consistent with those obtained by some authors (Acheampong et al, 2021; Callaghan et al, 2021; Dereje et al, 2022; Kahn et al, 2022; Allington et al, 2023). Our findings show how misinformation via social networks can affect health and healthcare demand. Unlike traditional news media platforms (TV, radio, print), social network content is pure and rarely scientifically verified, allowing misinformation and the spread of fake news to flourish, accompanied by the defense of conspiracy theories related to COVID-10 vaccines. Some of the common conspiracy theories that have dominated social media include the belief that the vaccine will be used to kill Africans so that Western countries can control their natural resources, or as a ploy by Bill Gates to implant microchips in the COVID-19 vaccine in order to control the world (Bangalee and Bangalee, 2021). Unfortunately, this misinformation is often spread by high-profile individuals. However, a good knowledge of COVID-19 can promote acceptance of the COVID-19 vaccine and reduce cases of disease (Gbeasor-Komlanvi et al, 2021; Ngoy et al, 2022).

In models 1 to 7, the coefficient of the "***ZON***" modality is negative and significant in the "***VCOV***" equation. This shows that the probability of accepting the COVID-19 vaccine decreases among people living in urban areas. Our result contradicts those of authors who claim that the area of residence does not significantly influence vaccine acceptance (Khubchandani et al, 2021; McElfish et al, 2021) and those who have shown that populations in rural areas are more likely to refuse the COVID-19 vaccine (Orangi et al, 2021).

In models 1 to 7, we note that the coefficients of the modalities of the variables "***TSTAT***", "***CCOV***", "***TSVCOV***" and "***EPCOV***" are positive and significant. This shows that vaccine acceptance increases with (i) confidence in the statistics published by the government about COVID-19, (ii) the control of corruption demonstrated by the government in pandemic management, and (iii) the individual's confidence in the government's ability to ensure the safety of COVID-19 vaccines and (iv) the effectiveness of COVID-19 vaccine compared to prayer. These results highlight the importance of the quality of government institutions in managing health crises. Some authors have shown that a lack of trust in government can affect COVID-19 vaccination (Orangi et al, 2021; Sato, 2022; Wiysonge et al, 2022). People who doubt the efficacy of the COVID-19 vaccine are also more likely to refuse the COVID-19 vaccine (Orangi et al, 2021). Similarly, Callaghan et al (2021) show that COVID-19 doubters, COVID-19 testers, and those who believe the COVID-19 vaccine is safe and effective are significantly more likely to choose the COVID-19 vaccine. McElfish et al (2021) argue that people who do not fear COVID-19 contamination are not willing to take the vaccine. Similarly, some authors (Orangi et al, 2021; Khubchandani et al, 2021) show that people who feel less exposed to COVID-19 contamination are more likely to refuse the vaccine. This pandemic has highlighted the need for robust health information systems that collect and use high quality, timely and reliable data, disaggregated by gender and other criteria, to identify gaps and highlight the plight of vulnerable populations in order to develop appropriate policies. It also highlighted the importance of transparency and the fight against corruption in the fight against this pandemic.

The coefficients of the modalities of the variable "***LDSCOV***" are negative and significant in the equation "***VCOV***" of models 1 to 7. This shows that people who are in favor of restrictions in the fight against COVID-19 are less inclined to accept the vaccine. According to the WHO, large-scale physical distancing measures and restrictions on movement, often referred to as "containment", can slow COVID-19 transmission by limiting contact between people. Our result shows that vaccine and containment are substitutes for individuals. Some individuals receiving government support in the form of family allowances or unemployment benefits may be tempted to refuse the vaccine in order to maintain government support.

In models 1 to 7, we find that the coefficient of the "*strongly supports*" modality of the "***COVSS***" variable is positive and significant. This means that people who support school closures as part of the fight against COVID-19 are more likely to accept the vaccine. This shows that individuals believe that vaccinating students, teachers, and parents is necessary for the resumption of face-to-face education in schools, which is more effective and efficient than online education, which can face many obstacles in African countries due to the poor quality of the Internet and difficulties in accessing NICTs.

We observe that the coefficient of the "*very fair*" modality of the "***DAHCOV***" variable is negative and significant in models 1 to 7. Consequently, individuals who believe that COVID-19 humanitarian aid has been distributed very fairly are less inclined to accept the vaccine. Our result shows that an equitable aid policy may induce some people to refuse the vaccine, which is likely to promote the resumption of economic activities. This may be the case when income from government aid exceeds net income from work.

Poverty impacts buffer

Tables 8 to 12 show that the coefficients of the 4 interaction variables "***PAUV*TSTAT***", "***PAUV*CCOV***", "***PAUV*TSVCOV***" and "***PAUV*EPCOV***" are positive and significant. These results show that vaccine acceptance among the poor increases when there is (i) confidence in the statistics published by the government about COVID-19, (ii) control of corruption displayed by the government in pandemic management, and (iii) individual confidence in the government's ability to ensure the safety of COVID-19 vaccines, and (iv) assurance of the effectiveness of COVID-19 vaccine compared to prayer.

By improving confidence in COVID-19 statistics, the government increases the likelihood that poor people will agree to be vaccinated. This underscores the importance of a reliable statistical system in managing health crises. According to the CDC Africa Survey (2021), only 18% of Africans consider government sources of information on COVID-19 to be reliable. Lachkar (2021) believes that statistical weaknesses in some African countries prevent a reliable assessment of the COVID-19 pandemic. The number of COVID-19 cases and deaths in Africa is severely underestimated. Weak statistical systems in many African countries already prevent proper registration of births and deaths (Lachkar, 2021). In most countries of the black continent, there are not many health facilities, especially in rural areas, capable of carrying out COVID-19 screening tests and immediately transmitting the information to the Ministry of Public Health, the only body authorized to publish these figures, with the risk of a lack of transparency, even if the WHO is vigilant.

By tackling corruption in pandemic management, authorities increase the likelihood that poor people will accept vaccination. The fight against COVID-19 has been marred by corruption in many African countries (Bargelès, 2020). Several reports prepared by the relevant authorities have carefully traced all the suspicious transactions carried out by public administrations in the fight against the pandemic. These include the over-invoicing of antiviral protective equipment, the purchase of substandard products, the awarding of public contracts to relatives, and the signing of public contracts with front companies.

By improving the safety of COVID-19 vaccines, health authorities are increasing the likelihood that poor people will accept the vaccine. Many African countries have suspended or paused the rollout of their vaccines due to safety concerns and a lack of vaccine storage infrastructure. Indeed, the fear of adverse effects reported in Europe and the United States has been at the root of most of these concerns (WHO, 2021). African countries often have limited capacity to monitor and report adverse events after vaccination, to investigate serious adverse events, and to communicate factual information about the benefits and risks of vaccines to their populations (WHO, 2021). The slow uptake of vaccines in Africa is often due to supply constraints, structural problems and logistical barriers (Prata Menezes et al, 2021). The delivery of vaccines to populations has often faced "transport and cold chain problems" and sometimes "wastage" of doses (Makooi and May, 2021).

By raising awareness of the effectiveness of the COVID-19 vaccine compared to prayer, the government can increase the likelihood that poor people will agree to be vaccinated. The Africa CDC survey (2021) found that COVID-19 vaccines are considered less safe by 32% of people. This figure rises to 45% in countries such as Gabon and Morocco. Religious communities are obviously an integral part of their communities and are often at the forefront of crisis response, both practically and pastorally. Experience from previous epidemics has shown that religious communities are particularly well placed to build trust and hope, counteract fear and strengthen community resilience, as well as individual mental and spiritual resilience.

Robust results

An analysis of the robustness of our results was carried out by replacing the recursive bivariate probit with a probit. We find that the coefficients of the variables measuring poverty, namely "***PAUVM***" and "***CASH***", are negative and significant in models 13 to 24. The coefficients of the 8 interaction variables "***PAUVM*TSTAT***", "***PAUVM*CCOV***", "***PAUVM*TSVCOV***", "***PAUVM*EPCOV***", "***CASH*TSTAT***", "***CASH*CCOV***", "***CASH*TSVCOV***" and "***CASH*EPCOV***" are positive and significant. There is a similarity with the results in Tables 3 and 5.

In models 13 and 19, all modalities of the variable "CPEC" are positive and significant. There are some differences with models 1 to 7. Also, all the modalities of the "***EDU***" variable are positive and significant at the 1% threshold. This result is similar to models 1 and 7. However, it differs from the results of models 2 to 6.

The coefficients of the "*Christian*" and "*Muslim*" modalities of the "***REL***" variable are negative and significant in models 13 and 19. Thus, Christians and Muslims are less likely to accept the vaccine. These results are similar to those in models 3 and 6. However, they are not similar to those of models 1 and 2.

In model 13, the variable "***EMPL***" has no significant effect on vaccine acceptance. On the other hand, the coefficient of "full-time work" modality has a positive and significant effect on vaccine acceptance in model 19. This was already the case in model 2.

As in models 1 to 7, the coefficient of the variable "***ZON***" is negative in models 13 and 19. This confirms that people living in urban areas are less likely to accept the vaccine. Furthermore, the coefficient of the variable "***AGE***" is positive and significant in models 13 and 19. This result is similar to that obtained in models 1 and 7.

The coefficient of the "*Every day*" modality of the "***SOME***" variable is negative and significant in model 13, as in models 1 to 7. However, the coefficient is not significant in model 19. The coefficients of the variables "***SEX***" and "***BRCOV***" are insignificant in models 13 and 19. However, in models 1, 2, 4, 5 and 7, these coefficients are positive and significant.

6. Conclusion

The study aims to examine the impact of good management of the COVID-19 pandemic on the uptake of COVID-19 vaccines among poor people in Africa. Methodologically, we used descriptive statistics and apparently unrelated bivariate probit regression techniques using the Afrobarometer (2022) database.

The econometric results show that poverty, in all its dimensions, significantly reduces the likelihood that an African will accept the COVID-19 vaccine. However, this negative impact of poverty changes with improved government management of the pandemic. In fact, the likelihood of accepting the vaccine among the poor increases significantly with (i) confidence in the statistics published by the government about COVID-19, (ii) the control of corruption demonstrated by the government in managing the pandemic, (iii) the individual's confidence in the government's ability to ensure the safety of COVID-19 vaccines, and (iv) the effectiveness of the COVID-19 vaccine in relation to prayer.

In light of the above, first, it would be prudent for African authorities to improve their systems for collecting, processing, and disseminating health statistics. No health system can function without quality information. But today, many African countries fail to register births and deaths or to collect other important information about the health of their populations. Health data is often patchy. The lack of quality data makes it difficult to make informed decisions about allocating resources to improve the fight against COVID-19. Data quality is essential to improve the quality of medical interventions for citizens and to enable strong, effective advocacy for rights and access to health care. To achieve this, African countries must invest in robust health and statistical information systems. They need to use technology to improve data collection and use. Mobile data collection can be chosen as it appears to be more efficient and ensures stricter control of data quality. It also avoids the burden of large amounts of paper, reduces the risk of loss, minimizes the risk of data entry errors, allows data to be exported directly into a spreadsheet or even provides a secure storage environment and allows the desired analyses to be performed directly. You also need to comply with a very strict legal framework governing the processing of personal data. Medical and social data fall under the definition of sensitive data and must be handled with great care. WHO must strengthen countries' health data capacity by bringing together different global partners to meet countries' needs, rather than adding to their workload.

Second, it seems useful to effectively combat the corruption observed in the management of the COVID-19 pandemic. Corruption can occur in any part of the health sector and occurs when people abuse their position for their own benefit, for the benefit of their organization, or for the benefit of their relatives. It can take many forms, including bribery, theft, or providing intentionally false or inaccurate information. Corruption can lead to a deterioration in the quality of care and make access to health care inequitable. According to Gaitonde et al. (2016), there is insufficient evidence on the best solutions to reduce corruption in the health sector. However, promising interventions include improvements in the detection of corrupt acts and repressive measures, especially efforts coordinated by an independent agency. Other promising interventions include policies that prohibit physicians from accepting benefits from the pharmaceutical industry, internal control practices in health facilities, and increased transparency and accountability for out-of-pocket payments combined with a reduction in incentives to seek informal payments.

Third, major efforts must be made to strengthen vaccine safety. As with all drugs, vaccine safety must be continuously monitored, even after the vaccine has been tested and introduced. This monitoring must take into account information from multiple sources. At the national level, these include vaccine recipients, parents or caregivers, and health care workers. This information is then reported to national health authorities. At the regional and global levels, WHO must strengthen its support to countries to collect and monitor this information and ensure that countries have the most up-to-date data on available vaccines. African governments must take decisive action to ensure that

logistics and infrastructure for storage and distribution are in place so that available doses of vaccine can be administered quickly and without waste.

Finally, the government must continue to raise awareness of COVID-19 by involving religious leaders in the vaccine's efficacy. This collaboration can help dispel conspiracy theories. In many countries, religious communities have been at the forefront of the fight against COVID-19. In the Democratic Republic of Congo, for example, the Bishops' Conference joined with the government to raise awareness among the Catholic faithful. It affirms that "*an effective response to this disease can only be achieved through strict compliance with the measures established by the competent authorities. We therefore invite all Congolese to apply them scrupulously in their family and professional environments. The recommended behavior is essential for all of us. We must constantly avoid the bad habits of insalubrity and adopt hygienic behaviors that protect everyone*". Government communication with the relay provided by the Ministers of Religion should focus on the global vaccine licensing process. It should be noted that, like all vaccines, those against COVID-19 undergo a rigorous, multi-stage testing process, including large-scale trials involving tens of thousands of people. An external panel of experts convened by WHO analyzes the results of the clinical trials, as well as factual data about the disease, age groups affected, disease risk factors, and other information. The panel recommends whether and how vaccines should be used. If a clinical trial indicates that a COVID-19 vaccine is safe and effective, a series of independent reviews of the efficacy and safety data is required. Part of this process will include a review of all safety evidence by the Global Advisory Committee on Vaccine Safety. It should also be noted that in developing vaccines against COVID-19, manufacturers and researchers have benefited from decades of experience in developing vaccines against other diseases, including Ebola. This has allowed COVID-19 vaccines to be developed and fully evaluated in clinical trials much more quickly than before. Unprecedented investment by governments and the private sector enabled vaccines to be developed and produced less than a year after the pandemic was declared. It is also important to communicate the benefits of vaccination to the public. COVID-19 vaccines provide protection against the disease by helping you develop an immune response to the SARS-Cov-2 virus. This immunity helps individuals fight the virus if they are exposed. Getting vaccinated also helps protect those around you, because if you're protected from infection and disease, you're less likely to infect others.

7. Annex

Table 4: Profile of the countries in the sample

Country	Population size	GDP per capita in US dollars
Benin	13 301 694	3 649
Botswana	2 350 667	16 304
Burkina Faso	21 382 659	2 394
Cape Verde	589 451	6 717
Cameroon	28 524 175	4 065
Côte-d'Ivoire	29 389 150	5 850
eSwatini	1 113 276	9 730
Gabon	2 284 912	15 175
Gambia	2 100 000	2 281
Ghana	32 372 889	5 971
Guinea	1 976 187	2 900
Kenya	54 685 051	5 211

Lesotho	2 177 740	2 521
Liberia	5 214 030	1 563
Madagascar	27 534 354	1 607
Malawi	20 308 502	1 638
Mali	20 137 527	2 329
Mauritius	1 386 129	23 035
Morocco	36 561 813	8 853
Mozambique	30 888 034	1 347
Namibia	2 678 191	10 038
Niger	23 605 767	1 303
Nigeria	219 463 862	5 408
São Tomé and Príncipe	213 948	4 451
Senegal	16 082 442	3 840
Sierra Leone	6 807 277	1 773
South Africa	56 978 635	14 624
Sudan	45 500 000	4 066
Tanzania	62 092 761	2 836
Togo	8 283 189	2 334
Tunisia	11 811 335	11 282
Uganda	44 000 000	2 467
Zambia	19 077 816	3 556
Zimbabwe	14 829 988	2 329
Total	858 896 174	193 447

Source: World Bank (2022)

Table 5: Econometric results of the bivariate probit (Poverty impacts buffer)

	Model 8		Model 9		Model 10		Model 11		Model 12	
	Coef.	**Std.Err.**	**Coef.**	**Std.Err.**	**Coef.**	**Std.Err.**	**Coef.**	**Std.Err.**	**Coef.**	**Std.Err.**
	Acceptance of the COVID-19 vaccine equation (VCOV)									
PAUVM (ref: Not poor)	-1.523***	0.071	-0.598***	0.020	-0.305***	0,017	-0,983***	0,021	-0,308***	0,018
PAUVM*TSTAT										
Poor and a bit trusting	0.156***	0.041	0.491***	0.028						
Poor and fairly confident	0.272***	0.046	0.810***	0.030						
Poor and very confident	0.421***	0.054	1.165***	0.033						
PAUVM*CCOV										
Poor and Corrupt Enough	-0.018	0.038			0.269***	0,027				
Poor and little corruption	0.161***	0.050			0.484***	0,033				
Poor and No corruption	0.272***	0.077			0.687***	0,046				
PAUV*TSVCOV										
Poor and trusting	0.883***	0.039					0,955***	0,029		
Poor and trusting enough	1.372***	0.046					1,445***	0,033		
Poor and very trusting	1.991***	0.058					2,109***	0,039		
PAUVM*EPCOV										
Poor and a little less effective	0.047	0.043							0,180***	0,029
Poor and as effective	0.264***	0.045							0,441***	0,031
Poor and a little more efficient	0.258***	0.050							0,491***	0,034
Poor and much more efficient	0.370***	0.056							0,538***	0,035
	Multidimensional Poverty Equation (PAUVM)									
CPEC (ref: Very poor)										
Quite bad	-0.075	0.048	0.085**	0.039	0.089**	0,041	0,088**	0,039	0,102***	0,039
Neither bad nor good	-0.251***	0.062	-0.076	0.049	-0.047	0,053	-0,092*	0,049	-0,058	0,049
Fairly good	-0.488***	0.047	-0.289***	0.037	-0.257***	0,039	-0,291***	0,037	-0,266***	0,037
Very good	-0.414***	0.075	-0.191***	0.057	-0.169***	0,061	-0,206***	0,058	-0,165***	0,058
SEX (ref: Female)	0.211***	0.036	0.256***	0.029	0.257***	0,031	0,254***	0,029	0,251***	0,029
EDU (ref: Illiterate)										
Primary education	0.128**	0.059	0.161***	0.045	0.170***	0,048	0,167***	0,045	0,159***	0,045
Secondary education	0.176***	0.056	0.121***	0.044	0.135***	0,047	0,128***	0,044	0,122***	0,044
Higher education	-0.091	0.065	-0.203***	0.053	-0.178***	0,056	-0,199***	0,053	-0,214***	0,053
REL (ref: Other religions)										
Christians	1.142***	0.047	1.071***	0.036	1.022***	0,039	1,069***	0,036	1,076***	0,037
Muslims	0.886***	0.049	0.833***	0.038	0.794***	0,040	0,822***	0,038	0,847***	0,038

EMPL (ref: Unemployed and not looking for work)										
Unemployment	0.569***	0.051	0.605**	0.041	0.613***	0,043	0,607***	0,041	0,605***	0,041
Part-time work	0.111**	0.056	0.097**	0.046	0.088*	0,049	0,100**	0,046	0,105**	0,047
Full-time work	-0.241***	0.046	-0.227***	0.037	-0.231***	0,039	-0,218***	0,037	-0,213***	0,038
ZON (ref: Rural area)	-0.207***	0.038	-0.179***	0.031	-0.174***	0,033	-0,188***	0,031	-0,186***	0,031
AGE	0.007***	0.001	0.010***	0.001	0.010***	0,001	0,010***	0,001	0,010***	0,001
SOME (ref: Never)										
Less than once a month	0.081	0.109	0.108	0.092	0.084	0,095	0,096	0,093	0,089	0,093
A few times a month	0.155	0.098	0.069	0.076	0.107	0,083	0,073	0,077	0,066	0,077
A few times a week	0.047	0.062	-0.056	0.050	-0.046	0,053	-0,059	0,050	-0,070	0,050
Every day	-0.291***	0.048	-0.388***	0.039	-0.383***	0,042	-0,387***	0,039	-0,391***	0,040
BRCOV (ref: No)	0.317***	0.038	0.331***	0.033	0.328***	0,034	0,330***	0,033	0,324***	0,033
RAHCOV (ref: No)	0.126***	0.039	-0.001	0.033	-0.012	0,035	0,006	0,033	-0,004	0,033
/athrho	-0.226***	0.024	-0.225***	0.020	-0.218***	0,021	-0,232***	0,020	-0,229***	0,020
rho	-0.222	0.023	-0.221	0.019	-0.215***	0,020	-0,228	0,019	-0,225	0,019
Wald test of rho=0: chi2(1)	6.070***		131.691***		110.085***		139.215***		134.082***	

NB: ***, ** and * represent significance at 1%, 5% and 10% respectively

Table 6: Probit model estimates of the determinants of vaccine acceptance (Robustness): part 1

	Model 13		Model 14		Model 15		Model 16		Model 17		Model 18	
	Coef.	**Std.Err.**	**Coef.**	**Std.Err.**	**Coef.**	**Std.Err.**	**Coef.**	**Std.Err.**	**Coef.**	**Std.Err.**	**Coef.**	**Std.Err.**
PAUVM (ref: not poor)	-1.881***	0.085	-2.038****	0.080	-1.003***	0.035	-0.721***	0.035	-1.414***	0.036	-0.701***	0.034
PAUVM*TSTAT												
Poor and a bit trusting	0.142***	0.042	0.167***	0.041	0.478***	0.026						
Poor and fairly confident	0.235***	0.047	0.281***	0.046	0.771***	0.029						
Poor and very confident	0.377***	0.056	0.429***	0.054	1.108***	0.032						
PAUVM*CCOV												
Enough corruption	-0.035	0.039	-0.019	0.038			0.265***	0.025				
Little corruption	0.137***	0.051	0.162***	0.050			0.477***	0.032				
No corruption	0.235***	0.078	0.289***	0.076			0.669***	0.044				
PAUVM*TSVCOV												
Poor and trusting	0.876***	0.040	0.885***	0.039					0.951***	0.028		
Poor and trusting enough	1.374***	0.047	1.378***	0.046					1.415***	0.031		
Poor and very trusting	1.988***	0.058	2.002***	0.057					2.078***	0.037		
PAUVM*EPCOV												
Poor and a little less effective	0.041	0.043	0.049	0.043							0.146***	0.028
Poor and as effective	0.256***	0.046	0.258***	0.045							0.375***	0.030
Poor and a little more efficient	0.238***	0.051	0.259***	0.050							0.446***	0.033
Poor and much more efficient	0.347***	0.058	0.360***	0.056							0.466***	0.034
CPEC (ref: Very poor)												
Quite bad	0.123***	0.038										
Neither bad nor good	0.200***	0.053										
Fairly good	0.312***	0.042										
Very good	0.171***	0.067										
SEX (ref: Female)	0.022	0.030										
EDU (ref: Illiterate)												
Primary education	0.255***	0.053										
Secondary education	0.207***	0.053										
Higher education	0.269***	0.062										
REL (ref: Other religions)												
Christians	-0.155***	0.052										
Muslims	-0.128**	0.056										
EMPL (ref: Unemployed and not looking for work)												
Unemployment	0.031	0.038										
Part-time work	-0.040	0.047										

Full-time work	0.060	0.042										
ZON (ref: Rural area)	-0.108***	0.031										
AGE	0.006***	0.001										
SOME (ref: Never)												
Less than once a month	-0.042	0.083										
A few times a month	-0.086	0.071										
A few times a week	-0.058	0.048										
Every day	-0.080**	0.040										
BRCOV (ref: No)	0.023	0.031										
RAHCOV (ref: No)	-0.044	0.034										
CONS	0.044	0.099	0.467***	0.037	0.414***	0.030	0.395***	0.032	0.416***	0.030	0.406***	0.030

NB: ***, ** and * represent significance at 1%, 5% and 10% respectively

Table 7: Probit model estimates of the determinants of vaccine acceptance (Robustness): Part 2

	Model 19		Model 20		Model 21		Model 22		Model 23		Model 24	
	Coef.	**Std.Err.**	**Coef.**	**Std.Err.**	**Coef.**	**Std.Err.**	**Coef.**	**Std.Err.**	**Coef.**	**Std.Err.**	**Coef.**	**Std.Err.**
CASH (ref: not poor)	-0,812***	0,041	-0,835***	0,036	-0,711***	0,033	-0,614***	0,034	-0,892***	0,033	-0,600***	0,033
CASH*TSTAT												
Poor and a bit trusting	-0,160***	0,037	-0,165***	0,035	0,154***	0,026						
Poor and fairly confident	-0,039	0,042	-0,031	0,040	0,403***	0,030						
Poor and very confident	0,126***	0,048	0,122***	0,046	0,809***	0,033						
CASH*CCOV												
Enough corruption	-0,144***	0,035	-0,143***	0,033			0,135***	0,027				
Little corruption	-0,047	0,044	-0,035	0,041			0,292***	0,035				
No corruption	0,000	0,061	0,038	0,058			0,521***	0,050				
CASH*TSVCOV												
Poor and trusting	0,568***	0,036	0,545***	0,034					0,381***	0,027		
Poor and trusting enough	1,020***	0,042	0,991***	0,039					0,880***	0,031		
Poor and very trusting	1,630***	0,051	1,599***	0,049					1,567***	0,039		
CASH*EPCOV												
Poor and a little less effective	-0,287***	0,039	-0,289***	0,037							-0,011	0,030
Poor and as effective	-0,056	0,043	-0,107***	0,041							0,289***	0,033
Poor and a little more efficient	0,006	0,046	-0,013	0,044							0,335***	0,036
Poor and much more efficient	0,012	0,046	-0,042	0,044							0,349***	0,037
CPEC (ref: Very poor)												
Quite bad	0,229***	0,031										
Neither bad nor good	0,371***	0,041										
Fairly good	0,485***	0,032										
Very good	0,364***	0,049										
SEX (ref: Female)	-0,019	0,024										
EDU (ref: Illiterate)												
Primary education	0,235***	0,038										
Secondary education	0,198***	0,038										
Higher education	0,281***	0,047										
REL (ref: Other religions)												
Christians	-0,096**	0,038										
Muslims	-0,175***	0,041										
EMPL (ref: Unemployed and not looking for work)												
Unemployment	-0,027	0,030										
Part-time work	-0,062	0,038										

Full-time work	0,083**	0,034										
ZON (ref: Rural area)	-0,094***	0,025										
AGE	0,006***	0,001										
SOME (ref: Never)												
Less than once a month	-0,033	0,066										
A few times a month	-0,010	0,055										
A few times a week	-0,011	0,039										
Every day	-0,033	0,032										
BRCOV (ref: No)	-0,028	0,025										
RAHCOV (ref: No)	-0,027	0,027										
CONS	-0,088	0,076	0,403***	0,032	0,414***	0,030	0,395***	0,032	0,416***	0,030	0,406***	0,030

NB: ***, ** and * represent significance at 1%, 5% and 10% respectively

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